NOVEMBER, 1949

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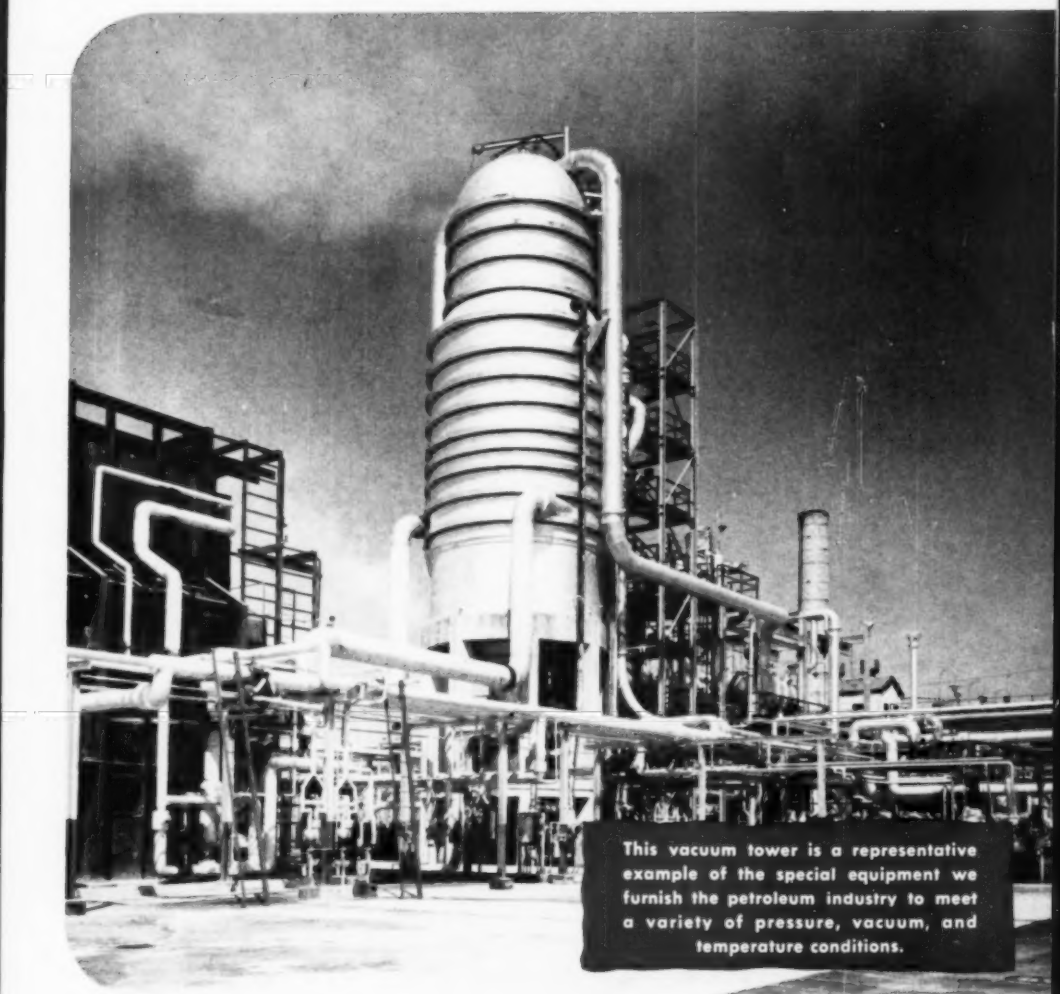

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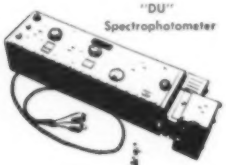
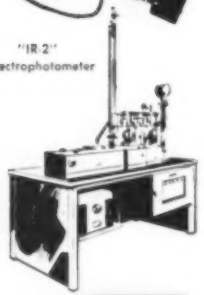


"IR-2"
Spectrophotometer



Model "R"
pH Indicator

OTHER BECKMAN INSTRUMENTS include the Photopen Recorder, the Ultrohmeter, numerous types of Radiation Meters, and other advanced equipment for specialized applications. For modern instrumentation needs bring your problem to Beckman.

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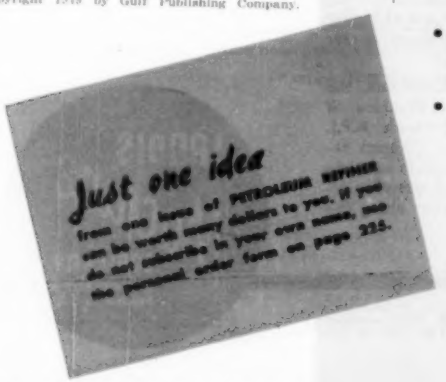
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VOLUME 28, NO. 11 — November, 1949

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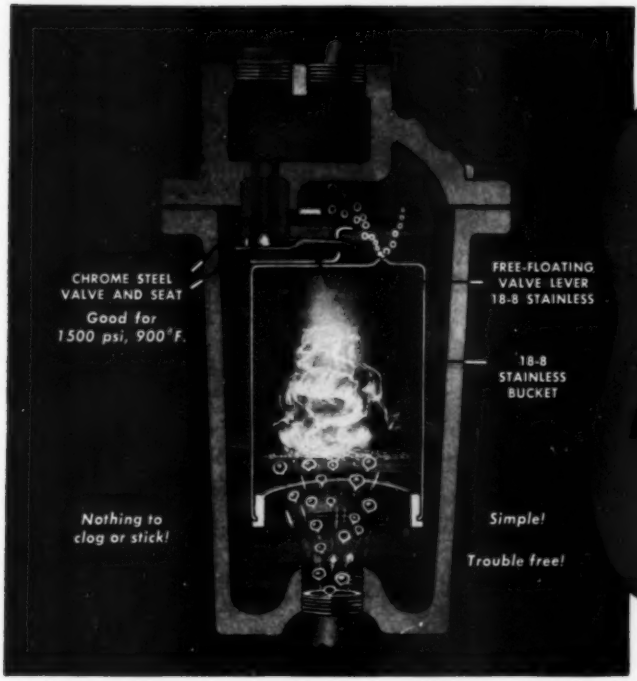
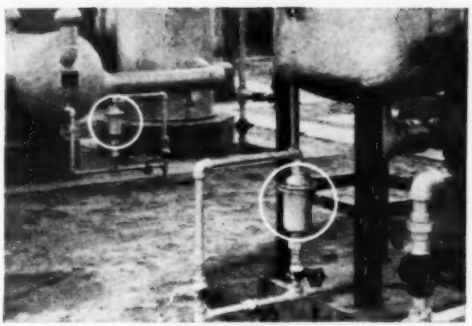


it isn't the cost or the upkeep with ARMSTRONG STEAM TRAPS



IF the first cost of Armstrong Steam Traps was high, which it isn't, they would still be a good buy because of low upkeep.* Maintenance on Armstrong Steam Traps is exceptionally low because:

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with Micrometer Indication

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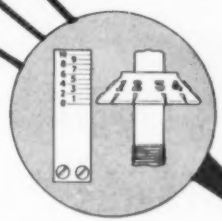

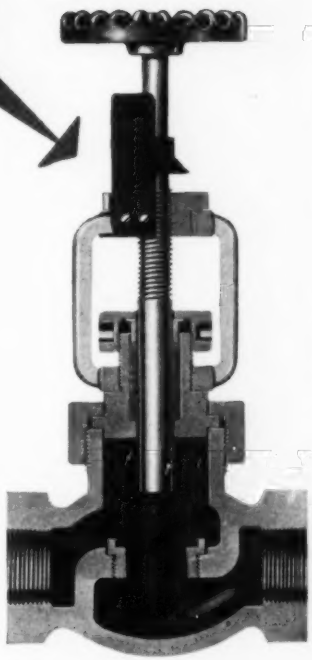

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**See illustration*

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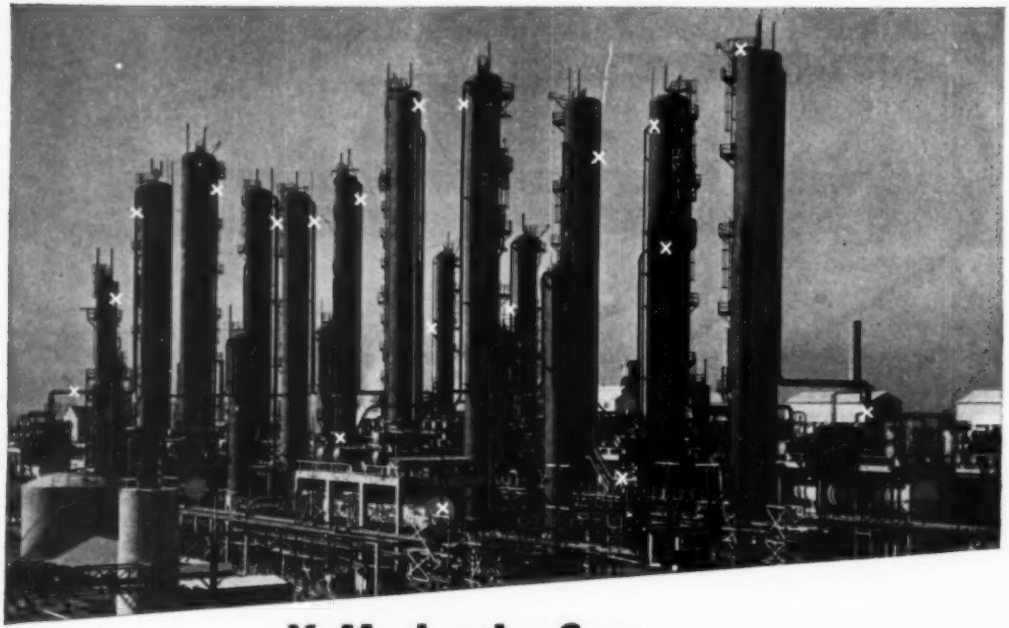

X Marks the Spots For Speedomax Pneumatic Control

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Speedomax Ended Control Difficulties

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Chicago, Illinois
• Central Steel & Wire Company
Phone: REpublic 7-3000
• Steel Sales Corporation
Phone: BIshop 7-7700

Cincinnati, Ohio
• Williams & Company, Inc.
Phone: CApitol 3000

Cleveland, Ohio
• Williams & Company, Inc.
Phone: UTah 1-5000

Columbus, Ohio
• Williams & Company, Inc.
Phone: MAin 3291

Dallas, Texas
• Metal Goods Corporation
Phone: DIxon 4-3525

Detroit, Michigan
• Steel Sales Corporation
Phone: TYler 6-3000

Houston, Texas
• Metal Goods Corporation
Phone: BEacon 3-0881

Kansas City, North, Missouri
• Metal Goods Corporation
Phone: WDrday 3510

Los Angeles, California
• Ducommun Metals and Supply Co.
Phone: Kimball 0161
• Pacific Metals Company, Ltd.
Phone: PRospect 0171

Newark, New Jersey
• Whitehead Metal Products Co., Inc.
Phone: BIgelow 8-0580

New Orleans, Louisiana
• Metal Goods Corporation
Phone: CAnal 7373

New York, New York
• Whitehead Metal Products Co., Inc.
Phone: WAtkins 4-1580

Philadelphia, Pennsylvania
• Edgcomb Steel Company
Phone: GArfield 3-6300

• Whitehead Metal Products Co., Inc.
Phone: BAldwin 9-7373

Pittsburgh, Pennsylvania
• Williams & Company, Inc.
Phone: CEdar 6060

Portland, Oregon
• Pacific Metal Company
Phone: BRoadway 0055

Rochester, New York
• Bruce-Mueller-Huntley, Inc.
Phone: GLenwood 0967

San Francisco, California
• Pacific Metals Company, Ltd.
Phones: Mission 7-1104
EMerprise 1-0808

Seattle, Washington
• Pacific Metal Company
Phone: MAin 6925

St. Louis, Missouri
• Metal Goods Corporation
Phone: CEntralNine 1234

Syracuse, New York
• Bruce-Mueller-Huntley, Inc.
Phones: SYracuse 73-3341 9-6621
• Whitehead Metal Products Co., Inc.
Phone: SYracuse 5-4112

Toledo, Ohio
• Williams & Company Inc.
Phone: ADams 0101

Tulsa, Oklahoma
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Selectivity!

Efficient H_2S removal in the presence of CO_2

The Shell Phosphate Process for gas or liquid purification has undergone successive improvements since its unusual advantages were first discovered.

Now it is practicable to remove all but harmless amounts of H_2S in the presence of large volumes of CO_2, while most of the CO_2 is left untouched.

The treating agent is inorganic, low in cost, and is not soluble in hydrocarbons. Since hydrocarbons being treated are not contaminated by the Shell Process treating solution, there are no harmful effects upon subsequent processing.

Regenerated H_2S is relatively pure because of its preferential removal in the first place . . . and because the inorganic treating chemical, having no vapor pressure, cannot contaminate the H_2S released in the stripper.

The Shell Phosphate Process is available to any operator under license from the Shell Development Company, Incorporated . . . together with experienced engineering service for its design, installation, and operation. Write for complete information.

SHELL DEVELOPMENT COMPANY, INCORPORATED

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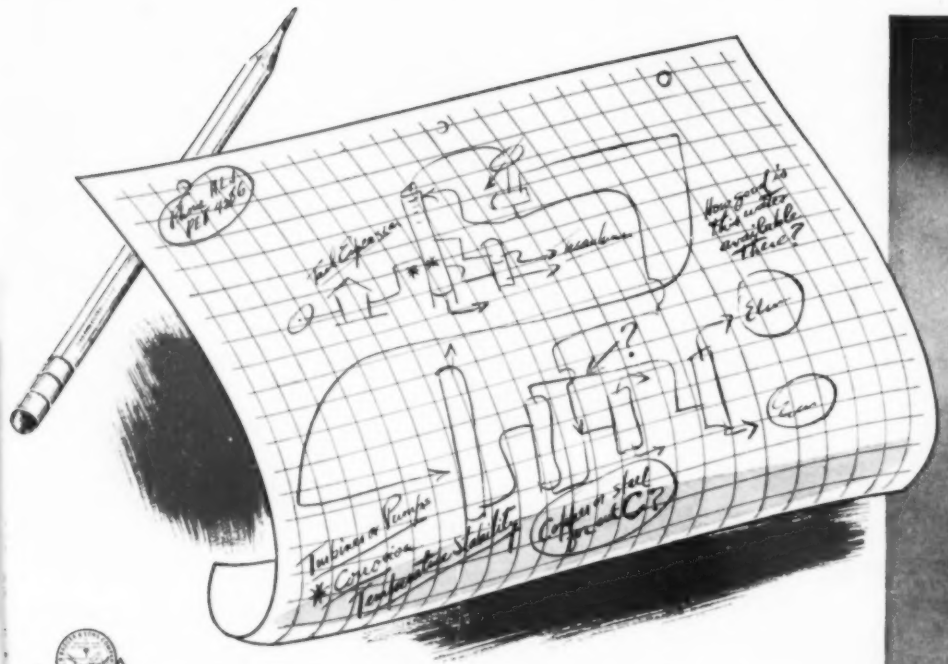

Whether you're planning to use a process still in the laboratory or one proved by years of commercial operation, Badger will develop with you its optimum application to your specific needs.

Badger's broad experience may thus be available during the planning and design stages of the project, and the responsibility for all phases of engineering, procurement of materials and erecting the plant are confined to one organization.

Badger believes that best results can be obtained by placing the responsibility for a process plant in one experienced organization and working in close cooperation and confidence with that organization . . . from the first "doodle" to the completion of the plant.

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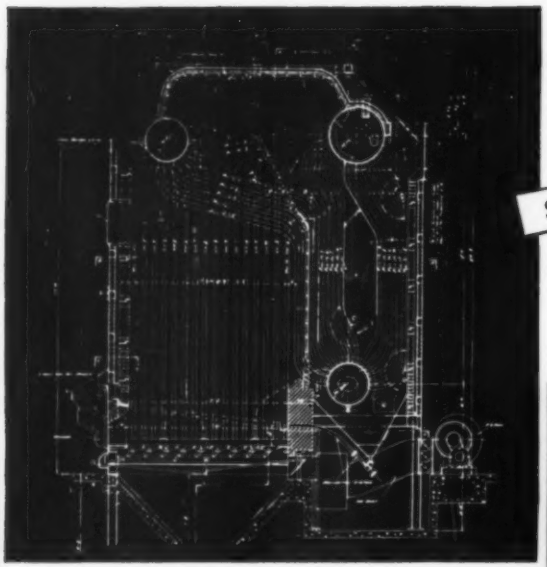
A SUBSIDIARY OF STONE & WEBSTER, INC.

PROCESS ENGINEERS and CONSTRUCTORS for the CHEMICAL, PETROLEUM and PETRO-CHEMICAL INDUSTRIES

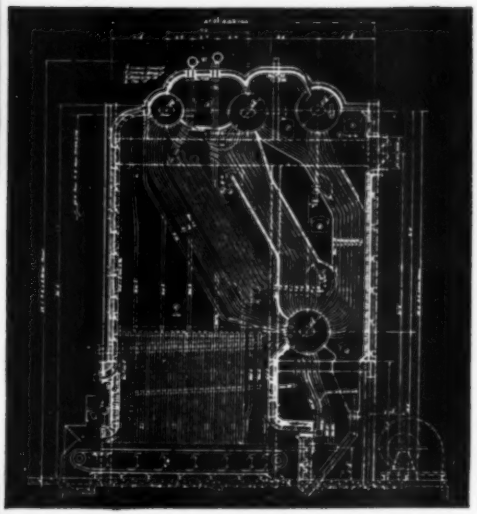
Quick Steaming at all Ratings!



Carry high overloads with high efficiency

SPECIFY **Vogt**

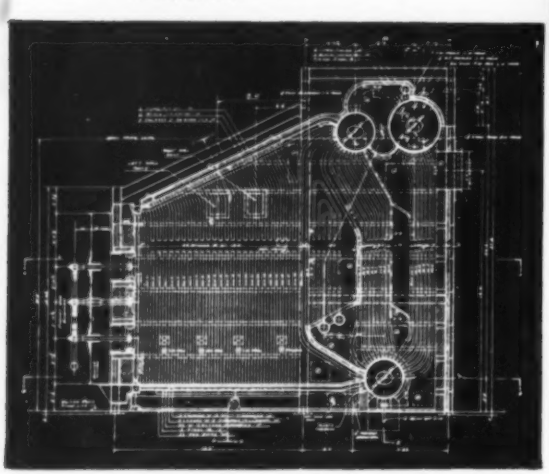
STEAM GENERATING UNITS



CLASS VL Two 27,500 pounds per hour units, installed at Brown-Forman Distillers Corporation, Louisville, Ky. Features large furnace volume in limited space, with high ratio of radiant heating surface.

CLASS LE Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnsue, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.



Vogt builds a complete line of bent tube steam generators, designed to burn solid, liquid, or gaseous fuels to meet specific operating conditions. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Bulletins with general information and showing typical installations are available upon request.

HENRY VOGT MACHINE CO.

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BRANCH OFFICES:
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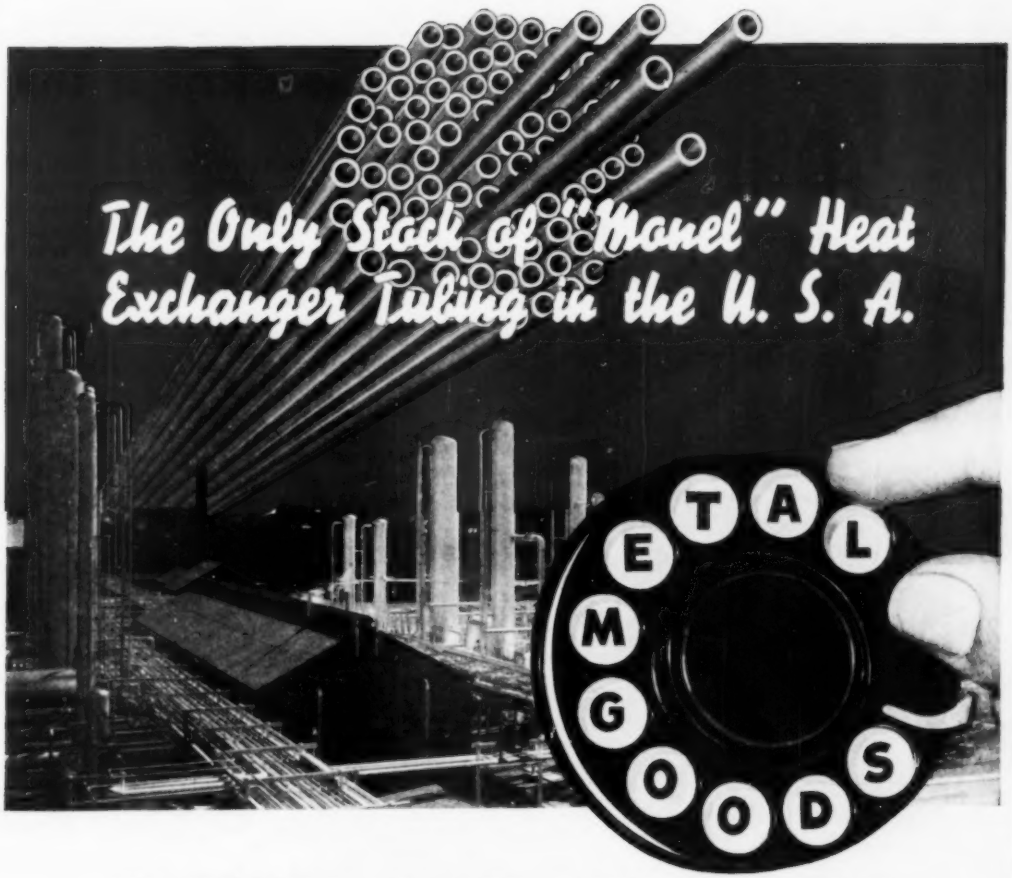

FOR IMMEDIATE SHIPMENT — CALL METAL GOODS

Now you can put corrosion-resistant Monel* Heat Exchanger Tubing to work for you — without delay! A stock of ¾" OD x 0.065" (16 BWG) and 0.083" (14 BWG) wall x 16' long Monel* Tubing is on hand for fast delivery from our Houston warehouse.

Where high corrosion resistance plus strength and toughness are needed . . . count on Monel* for *all* these advantages:

- **Readily fabricated, and expanded into Tube Sheets.**
- **High resistance to hydrogen sulfide, hydrochloric acid, sulfuric acid and brine. Withstands hydrofluoric acid in HF alkylation.**
- **Resists effects of cavitation and impingement.**
- **Stands up in caustic soda reboilers and in condensers for chlorinated solvents and furfural.**

For shipment TODAY . . . phone, wire or write your nearest Metal Goods warehouse.

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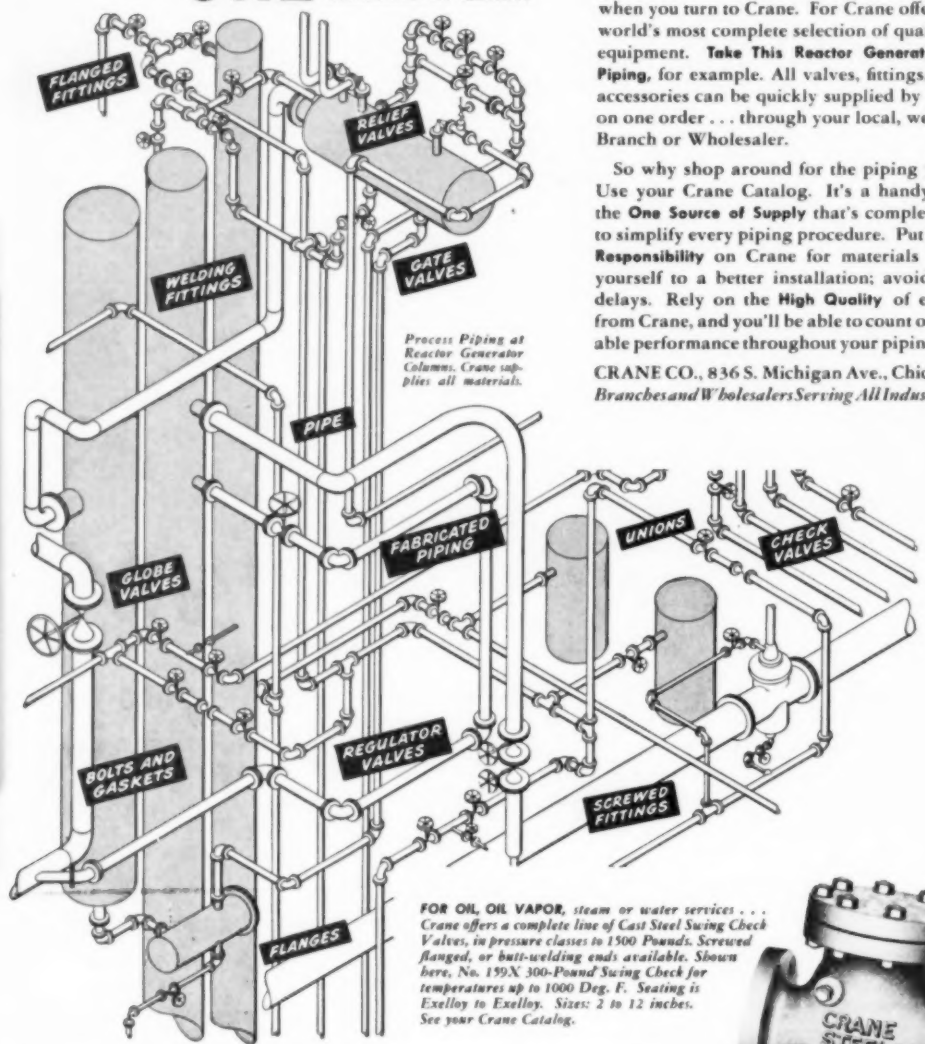
If it's piping equipment for refineries ...It's in the CRANE line

ONE SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



Process Piping at Reactor Generator Columns. Crane supplies all materials.

Whether you need piping for power, process or general service installations, you can't go wrong when you turn to Crane. For Crane offers you the world's most complete selection of quality piping equipment. **Take This Reactor Generator Column Piping,** for example. All valves, fittings, pipe and accessories can be quickly supplied by Crane . . . on one order . . . through your local, well-stocked Branch or Wholesaler.

So why shop around for the piping you need? Use your Crane Catalog. It's a handy index to the **One Source of Supply** that's complete enough to simplify every piping procedure. Put **Undivided Responsibility** on Crane for materials and help yourself to a better installation; avoid needless delays. Rely on the **High Quality** of every item from Crane, and you'll be able to count on dependable performance throughout your piping systems.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

FOR OIL, OIL VAPOR, *steam or water services . . . Crane offers a complete line of Cast Steel Swing Check Valves, in pressure classes to 1500 Pounds. Screwed flanged, or butt-welding ends available. Shown here, No. 159X 300-Pound Swing Check for temperatures up to 1000 Deg. F. Seating is Exelloy to Exelloy. Sizes: 2 to 12 inches. See your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

When the erection of a plant gets underway—most of the gains from efficient construction technique have already been won—or lost! Ultimate savings are largely set in the *planning* of the construction program—as to methods, schedules and labor requirements.

At Lummus, this planning is derived from unsurpassed 'round-the-world experience. Then, it is put into practice by a field staff to whom so-called "unpredictables" are old and familiar.

Sound technique, as Lummus applies it, means a sound night's sleep for those we serve who shoulder the responsibility.

LUMMUS designs and builds with

economy
fulfillment
resourcefulness
teamwork
TECHNIQUE
perspective

TECHNIQUE— in planning

The full effect of detailed planning in advance of actual construction has been realized in foreign work where local facilities are at a minimum. It called for scheduled arrival of tools and materials, periodic estimates of manpower requirements and the preplanning of specific procedures for materials handling and heavy lifts. Economy in requirements for construction facilities, tools and equipment by preplanned re-use at various construction stages is one example. The selection of a supervisory staff with experience permitting effective reassignment as the job progresses is another.

TECHNIQUE— on the job

What makes it possible to move a 150-ton derrick intact from one tower-erection location to another, as contrasted to disassembly and reassembly? Planning—plus practical experience of the field staff on the job! Lummus field personnel has served in some 15 foreign fields, as well as at home, and averages better than 10 years' Lummus experience.

TECHNIQUE— as to costs

From an analysis of unit erection costs in which every man-hour is estimated in advance, Lummus lays the groundwork for continuing cost control. Periodic reports, detailing costs and work-progress, permit evaluation of all phases of the job from start to finish.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
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The Lummus Company, Ltd., 525 Oxford St., London, W-1, England

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Compañia Anónima Venezolana Lummus—Edificio "Las Gradillas"
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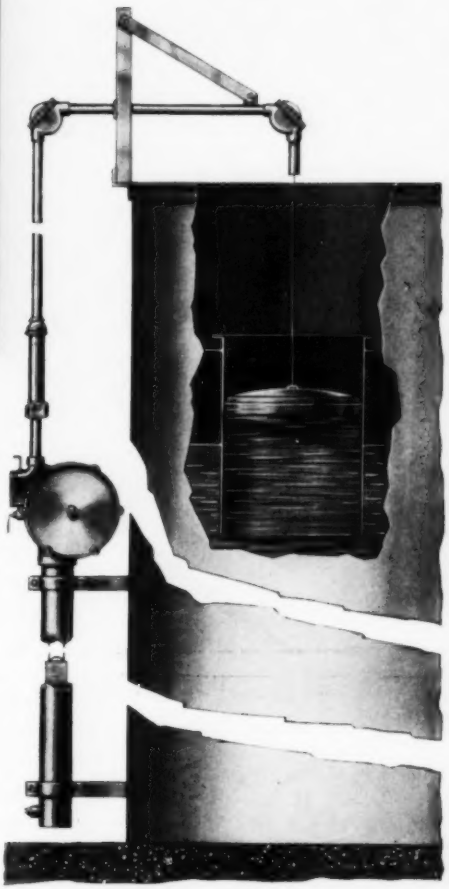
S&J AUTOMATIC GAUGES FOR *Floating Roof* TANKS ARE

Economical
Accurate
Safer



Shand & Jurs Automatic Tank Gauges for floating roof tanks give you repeated, consistently accurate readings, from which the human element is entirely eliminated. The gauger merely needs to read the tape and record the reading.

In taking tank readings from the ground level you save the time and eliminate the hazards of climbing up and down ladders or steps; you obviate damage to tank tops; hazards of explosion and asphixiation are not present; and there is no loss of valuable vapors as must necessarily accompany manual gauging through open hatches.

The saving in time soon amortizes the cost of automatic tank gauges—the savings in vapors and the greater safety are just velvet. We make automatic gauges for petroleum storage tanks of all types, shapes and operating pressures. Tell us what you require and we will send full information promptly.

SHAND & JURS CO.
BERKELEY, CALIFORNIA

NEW YORK **CHICAGO** **HOUSTON** **LOS ANGELES** **SEATTLE**

SHAND & JURS

When ordering condenser tube

DO YOU SPECIFY SIZE AND ALLOY ONLY ?

Tube is more than size and alloy. Such information must appear on your order, of course, to satisfy a mechanical requirement.

But really, the main part of any specifications lies in the name of the manufacturer you choose to supply the tube. *That* must be your first consideration, for upon *that* depends the service you can expect from the tube after it is installed.

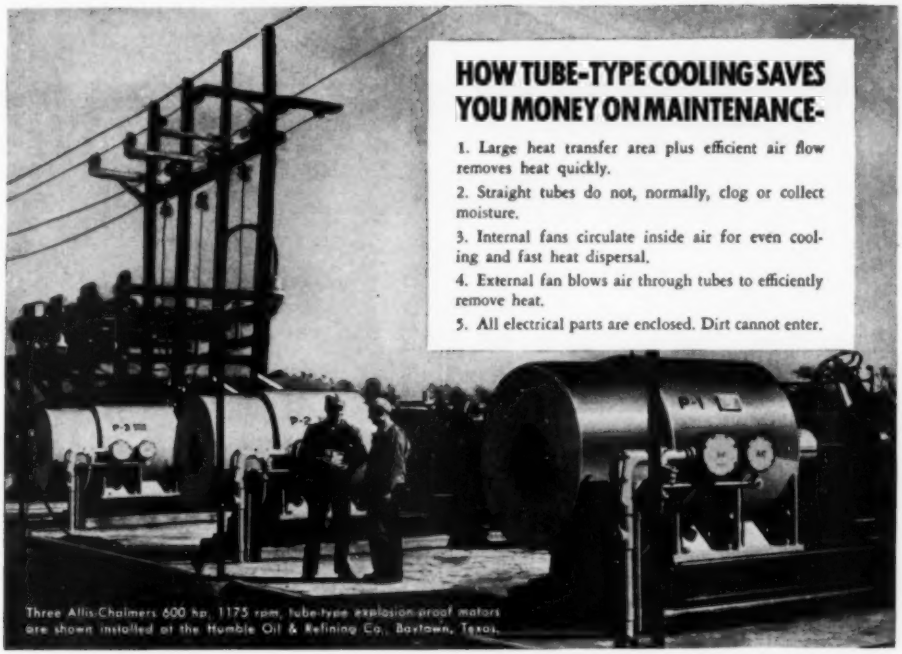
It is to your advantage, therefore, to specify *Wolverine* on your orders for condenser tube. This name stands for quality-control and assures you of dependability far beyond what you would normally expect.

There IS a difference in tubing, you know

WOLVERINE TUBE DIVISION
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED
MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING

1431 CENTRAL AVENUE • DETROIT 9, MICHIGAN

New A-C Tube-Type Motors Used By 18 Leading Petroleum Companies!


HOW TUBE-TYPE COOLING SAVES YOU MONEY ON MAINTENANCE-
1. Large heat transfer area plus efficient air flow removes heat quickly.
2. Straight tubes do not, normally, clog or collect moisture.
3. Internal fans circulate inside air for even cooling and fast heat dispersal.
4. External fan blows air through tubes to efficiently remove heat.
5. All electrical parts are enclosed. Dirt cannot enter.
Three Allis-Chalmers 600 hp, 1175 rpm, tube-type explosion-proof motors are shown installed at the Humble Oil & Refining Co., Baytown, Texas.

OVER ONE THIRD of Allis-Chalmers tube-type, explosion-proof motors have been purchased by 18 of the world's leading petroleum companies! . . . Proof that petroleum operators want these important features:

1. APPROVED BY UNDERWRITERS' LABORATORIES for ratings to *450 hp at 3600 rpm.* Motors of similar design are offered in larger sizes. This new, tube-type motor is the simplest explosion-proof design now offered in the very large sizes.

2. MOTOR IS SELF-CLEANING because of straight flow of cooling air — avoiding hidden recesses encountered in usual designs. If unusual operating conditions make cleaning desirable, motors can be cleaned while in operation — simple as cleaning your shotgun with a ramrod!

3. QUIET OPERATION because of improved fan design . . . straight flow of cooling air . . . smaller quantity of cooling air required by effective radiation system.

4. LIGHTER WEIGHT, YET MORE EFFICIENT! Elimination of heavy shell castings reduces motor weight . . . no sacrifice of electrical performance.

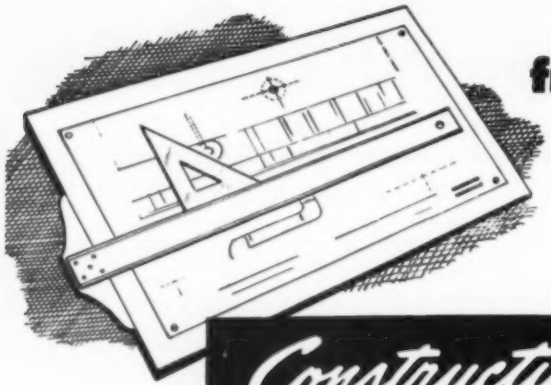
You'll want more information on how this *new* motor can help save maintenance dollars! Send for Bulletin 51R7149.

ALLIS-CHALMERS, 1062A SO. 70 ST.
MILWAUKEE, WIS.

Texrope is an Allis-Chalmers trademark.

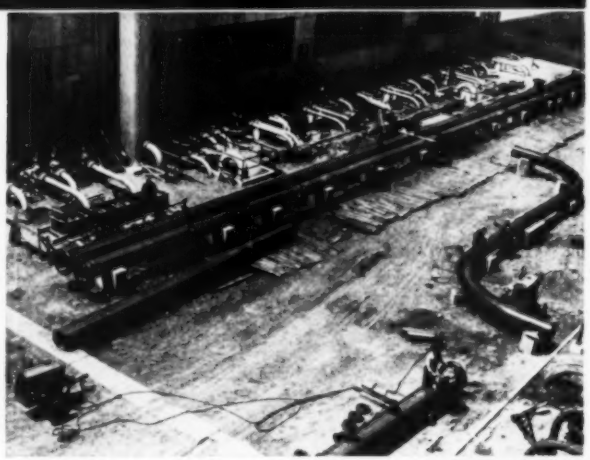
ALLIS-CHALMERS

A-2788



from drawing board to finished job . . .

Construction by GRAVER

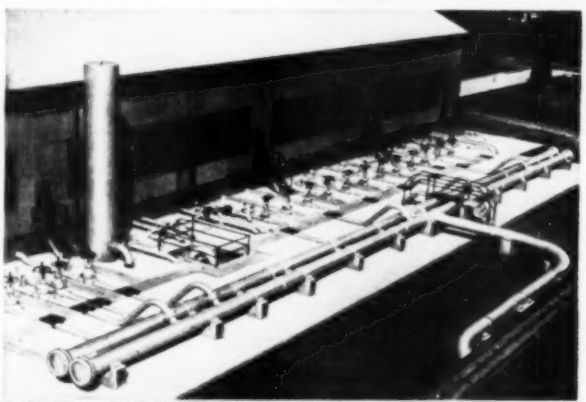


■ Graver Construction Service goes all the way to meet the requirements of the petroleum and process industries — from engineering and planning . . . through material procurement . . . to finished erection.

This complete service covers every step of practically any type or size of project — refinery units or complete refineries . . . piping . . . process equipment dismantled and re-erected . . . pipe line terminals . . . pipe line pumping stations . . . chemical plants . . . recovery plants . . . auxiliary equipment for synthetic rubber plants . . . auxiliaries to all types of refinery equipment.

Experienced personnel and full equipment are maintained at strategic locations for jobs involving foundations . . . structural steel . . . erection of heavy vessels . . . piping . . . brick work . . . painting . . . machinery setting . . . instrument boards . . . and electrical work.

No matter what your requirements may be — maintainance and repair . . . expansion or modernization of existing equipment . . . installation of new facilities — get in touch with the nearest Graver office *at once*.



GRAVER CONSTRUCTION CO.

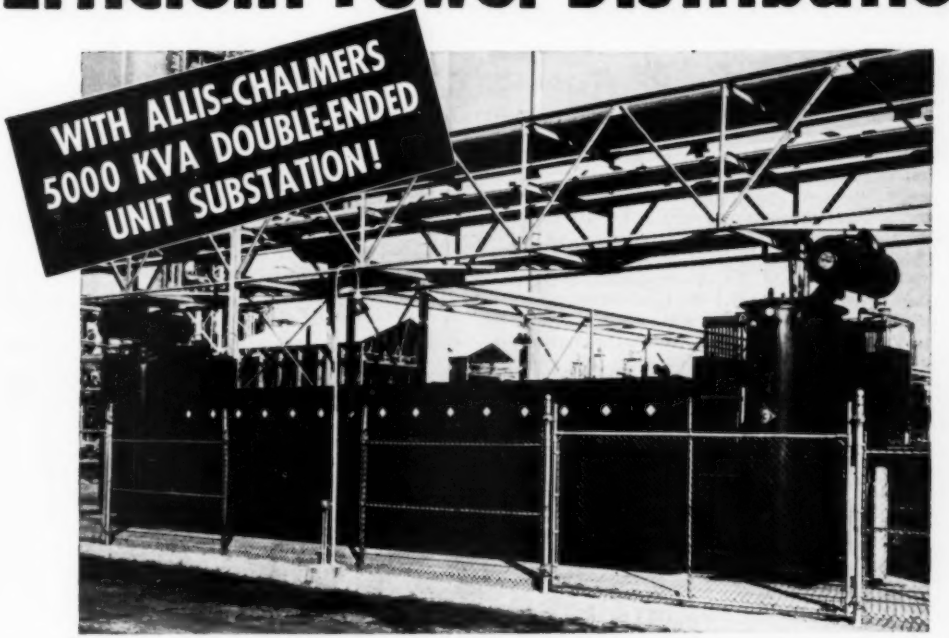
424 Madison Avenue, New York 17, New York

GRAVER

CHICAGO — ENGINEERING DEPT. 880 BERGEN AVENUE, JERSEY CITY, NEW JERSEY — HOUSTON

A DIVISION OF GRAVER TANK & MFG. CO., INC. EAST CHICAGO, IND.

Shell Oil Refinery Gets Safe, Efficient Power Distribution



DESIGNED FOR QUICK INSPECTION—LOW MAINTENANCE

ELECTRIC POWER SUPPLY is protected and distributed at the Shell Oil company refinery, Deer Park, Texas, by this 5000 kva double-ended Allis-Chalmers Unit Substation consisting of two 2500 kva transformers and a 12 feeder section of switchgear.

Shell Oil company gets these results: ▸ pleasing appearance; ▸ maximum safety for workmen; ▸ reduced maintenance and inspection; ▸ compactness; ▸ flexibility for expansion.

Every part of this Allis-Chalmers Unit Substation is built with attention to details of construction and arrangement that result in maximum protection . . . quicker inspection . . . reduced maintenance.

Devices like potential and control transformers that are *drawout mounted* for greater accessibility — finger-type disconnects located on the *removable breaker element* for ease of inspection — are good points to compare when buying unit substations for your electric power distribution system.

You gain initially with less paper work, quicker installation for added economy. Allis-Chalmers assumes undivided responsibility for performance of the *complete* substation! Call your nearby A-C representative. Or, write direct.

A-2873

ALLIS-CHALMERS, 1062A SO. 70 ST.
MILWAUKEE, WIS.

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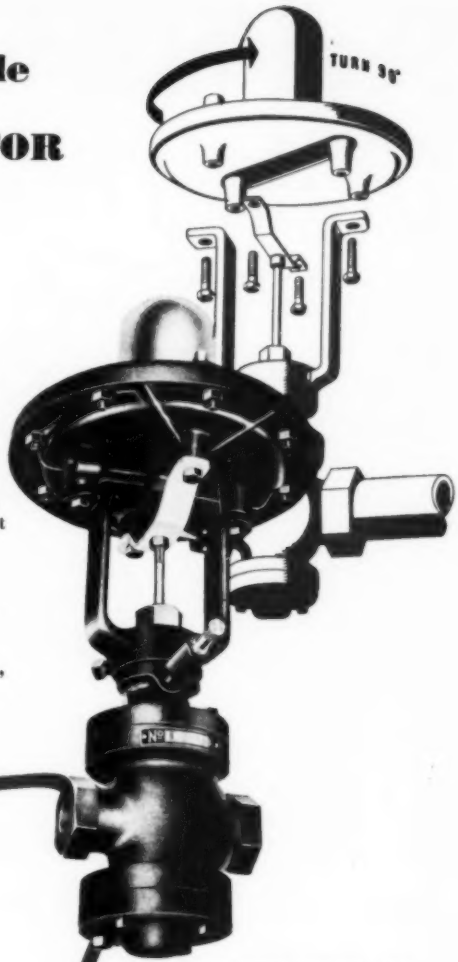
A-C ALLIS-CHALMERS

ALLIS-CHALMERS

Power, Electrical, Processing Equipment for Petroleum Industry

NEW! Quick-Reversible STABILFLO VALVE MOTOR

makes a 2-in-1 control valve



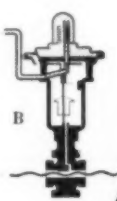
By a simple, ingenious application of relative-motion principles, Foxboro has developed a new valve motor to provide foolproof, almost instant reversibility of valve action. With it, valve action can be changed in four simple steps . . . unbolting diaphragm motor, rotating motor 90 degrees, rebolting motor and shifting air connections. That's all!

This new diaphragm motor brings you *convenience* never before available. It makes it possible to reduce valve *inventories*. And it permits you to standardize, throughout your plant, on the friction-free floating power that has helped make Foxboro Stabilflo Valves the standard of performance in all process industries.

Get all the facts about this new cost-saving development. Write for Bulletin on Quick-Reversible Stabilflo Valve Motor . . . the motor that now makes possible a 2-in-1 control valve. **The Foxboro Company, 74 Neponset Ave., Foxboro, Mass., U. S. A.**

Diagram A shows air-to-close action of a typical Foxboro valve body equipped with the new reversible motor. Yoke is rigidly attached to diaphragm motor housing and valve stem moves integrally with diaphragm plate. Air pressure is always on the same side of diaphragm whether on an air-to-close or air-to-open action.

Diagram B shows air-to-open action. Here motor has been turned 90 degrees. Now mounting lugs of diaphragm motor housing, originally bolted to yoke, are bolted to valve stem strap and lugs on diaphragm plate are bolted to yoke. Although diaphragm plate is rigidly attached to yoke, the diaphragm is free to move.



QUICK-REVERSING ON LINE. No need to remove, reverse and re-install valve

NO SPECIAL TOOLS NEEDED. Simple job . . . standard tools

NO MECHANICAL SKILL NEEDED. Valve action can be changed without services of a specialist

A DUAL-PURPOSE, QUALITY VALVE. Now, the widely-used Stabilflo Valve featuring 50-to-1 rangeability with uniform characteristics is available with this new cost-saving feature that makes it 2 valves in 1.

FOXBORO
REG. U. S. PAT. OFF.

STABILFLO CONTROL VALVES

ARE YOU A WATER TREATMENT

Skeptic?

Some operating engineers say, "Water treatment organizations? They're as alike as peas in a pod!" Other, *more constructive* skeptics wonder, "Am I getting all I should from my present service?"

Whichever kind of skeptic you are, you'll find that all water treatment organizations are *not* alike . . . that quality of service *does* vary, even though the cost may be practically the same. That's why you should be sure you know all that Bird-Archer has to offer. Keep a skeptical eye open, if you wish, as you study the Bird-Archer 8-Point Water Treatment System listed on the right. Compare it, point by point, with your present service.

THE BIRD-ARCHER 8-POINT WATER TREATMENT SYSTEM

ALL OR ANY PART OF THIS SERVICE IS AVAILABLE TO YOU

1. **Plant Survey**
2. **Study of all available water with particular relation to use**
3. **Development of treatment and control systems**
4. **Furnishing properly prepared treatment materials**
5. **Specifying any equipment that may be necessary**
6. **Instructing plant staff in the operation and control of the treatment system**
7. **Continuous supervisory service**
8. **Laboratory service for scientific analysis**

Were you honestly critical? Did you find something lacking? Even if you operate a relatively small plant, you can get the same careful attention and completeness of service as the largest central station plants enjoy.

Take the first step. It involves no obligation. Simply fill in the coupon and mail it today.

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WATER TREATMENT

THE BIRD-ARCHER COMPANY • 400 MADISON AVE., NEW YORK 17, N. Y.
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THE BIRD-ARCHER COMPANY, 400 MADISON AVENUE, NEW YORK 17, N. Y.

Gentlemen: Please have your Field Engineer call and make a free basic survey of our water treatment requirements. I understand there is no obligation.

NAME _____ POSITION _____

COMPANY _____

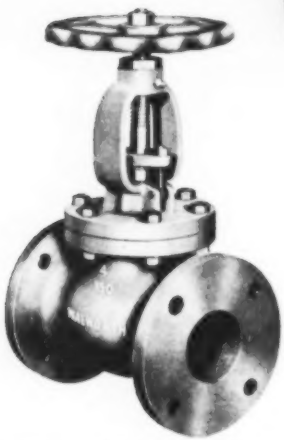
ADDRESS _____

_____

Newly Designed Walworth Valves to combat corrosion

Walworth 150-pound Stainless Steel Gate Valve . . . available in sizes ½ to 3-inch, screwed; ½ to 12-inch, flanged.

Made of Stainless Steel
Monel · Nickel
Acid-resisting Bronze
Ni-resist



Walworth 150-pound Stainless Steel Globe Valve . . . available in sizes ½ to 3-inch, screwed; ½ to 6-inch, flanged.

— ENGINEERED AND TESTED FOR TOUGH . . . HARD SERVICE

Walworth offers a comprehensive line of valves made of several cast stainless steels and special alloys for piping services where corrosion is a factor. These valves are available in Gate, Globe, Angle, Check, and Lubricated Plug types.

Gate, Globe and Angle Valves have outside screw and yoke construction, thus keeping the stem threads out of contact with the corrosive material in the line. They also have a two-piece bolted gland with ball-type gland follower to prevent binding the stem when packing bolts are tightened. Gland eye-bolts can be conveniently swung out of the way without danger of loss when the gland is lifted for repacking.

Gate Valves have taper seats with a unit consisting of two flat faced discs supported by a carrier on the end of the stem. The discs are of a proven ball-and-socket type. They are free to rotate and adjust themselves to the body seat angles, assuring tight seating with no possibility of sticking in any position.

For further information about Walworth's full line of corrosion-resistant valves, see your Walworth distributor.

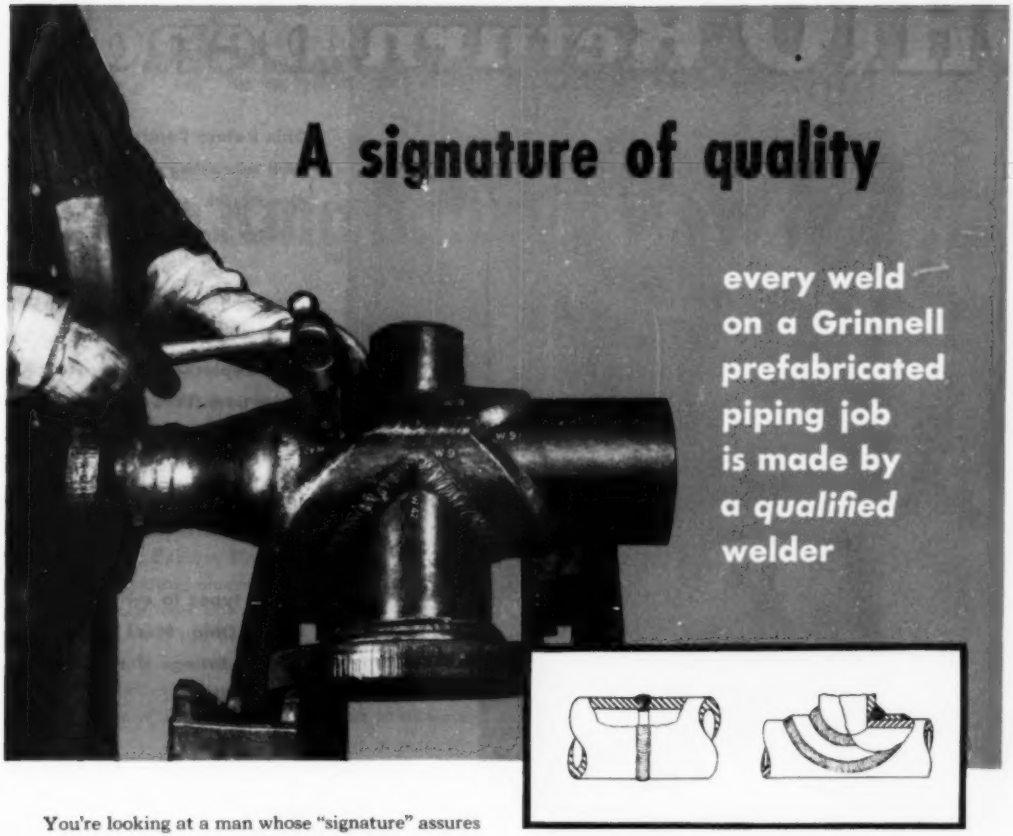
Sectional view of Walworth 300-pound Stainless Steel Gate Valve . . . available in sizes 2 to 6-inch, flanged.

WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD



You're looking at a man whose "signature" assures quality welding of piping. He's a Grinnell welder and, as every Grinnell welder, he is qualified by Grinnell according to a procedure which conforms to A.S.M.E. Boiler Construction Code, Section 9. After qualifying, he is given a number which he "signs" adjacent to each weld he makes.

Quality welding is only one of a long chain of responsibilities assumed by Grinnell on every prefabricated piping job . . . from the interpretive engineering to the on-time delivery of the fabricated piping. Such responsibility requires facilities for metallurgical research and testing, comprehensive knowledge of state laws and industry codes, and a complete familiarity with insurance company requirements for fabricated piping.

The fabrication of piping for today's high pressure, high temperature or corrosive services is a job for experts. It's a job for Grinnell prefabricating plants because Grinnell has the modern equipment and methods, and the skilled personnel which enable them to assume total responsibility for the job.

99 YEARS PIPING

GRINNELL

Grinnell Company, Inc., Providence, Rhode Island. Branches: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston Long Beach • Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

OHIO Return Bends

TYPE 2000

Ohio Return Bends are designed to take advantage of the principle of directional solidification to give greater strength.

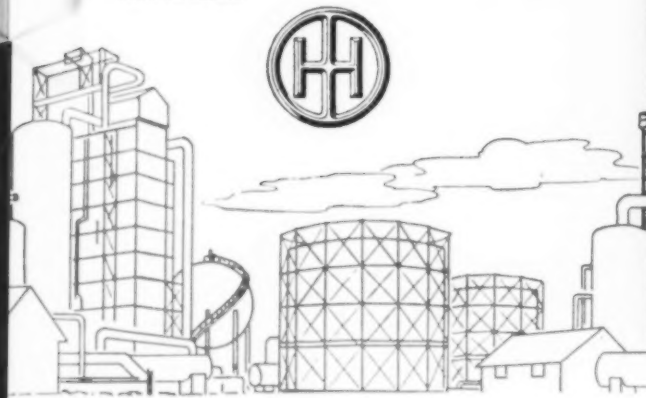
TYPE 2000 does not require rolling jigs for installation. Ease of single tube replacement saves valuable down time. TYPE 1000 is adaptable to wide general use under most operating conditions since materials in body and plugs are varied to suit individual needs.

Other types to suit many applications. Ohio Steel also produces special fittings if required. Write for details.

TYPE 1000

FAHRITE TUBE SUPPORTS

Where there's extreme heat for long periods of time, FAHRITE tube sheets, supports and hangers meet necessary strength requirements. They're field-proved. One of the many grades of FAHRITE will suit your operating conditions. Write for details.



The Ohio Steel Foundry Co.

SPRINGFIELD, OHIO Plants at Springfield and Lima, Ohio

ACCURATE RECORDS *with*

Hagan Ring Balance Flow Meters

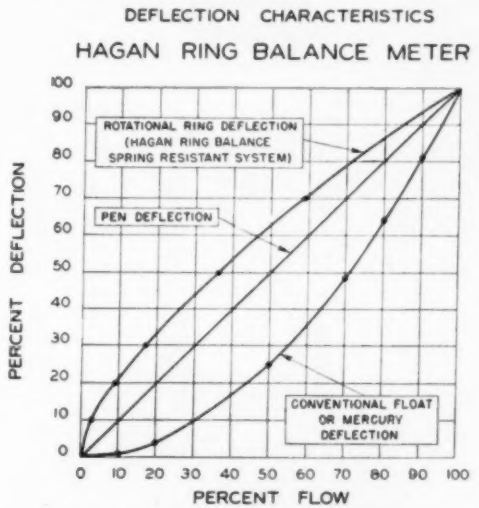
In many flow metering applications, there are considerable periods when flow is only a very small percentage of maximum. Nevertheless, it may be highly important to have a reliable record of flow at *all* times, including these low flow periods.

You can get such records with the Hagan Ring Balance Flow Meter.

This low-flow response is inherent in the design of the Hagan Ring Balance Meter. The ring, pivoted on a knife-edge bearing, moves in response to extremely low differentials, and this ring movement is proportionately *greater* at low flows than at high.

Since flow is a square root function of differential pressure, all orifice type meters require correction of the movement of the measuring element in order to produce a linear chart. In conventional meters, the correction is a *multiplication* of this movement, and hence a multiplication of any error. In Hagan Ring Balance meters, however, the corresponding ring movement is greatest at the lower end of the scale. Therefore possible inaccuracies are minimized instead of multiplied on the chart record.

For full information on this and other features of Hagan Ring Balance Meters—including Dual meters which record two flows on a single chart—write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.



Graph shows how compensating mechanism of Ring Balance meters reduces movement of pressure responsive element, while in conventional meters this must be magnified to produce a linear flow chart.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

Hagan Corporation
Hagan Building
323 Fourth Avenue
Pittsburgh 30, Pa.

Please send me further information on Hagan Ring Balance Flow Meters. I am particularly interested in _____

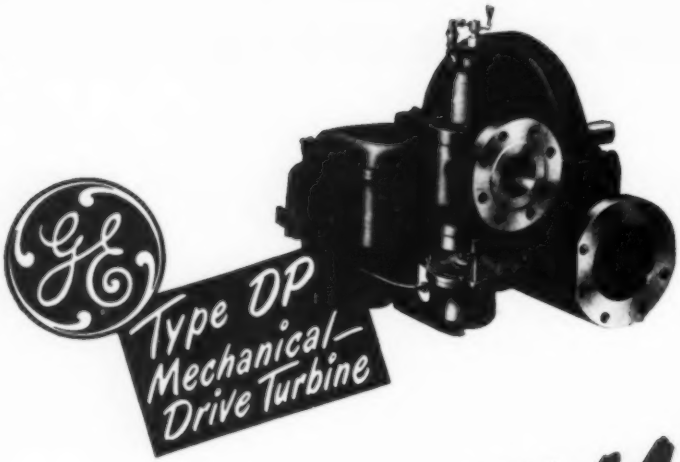
NAME _____

COMPANY _____

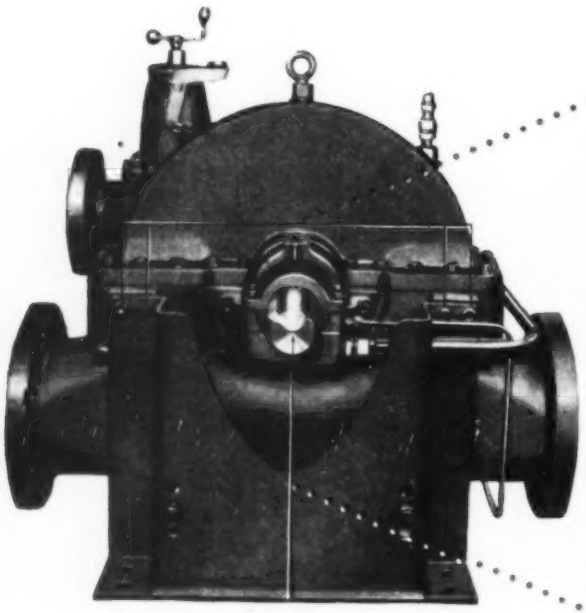
STREET _____

CITY _____ STATE _____

PR-11



SAVE TIME ON



Turbines supported at the centerline save many mis-alignment headaches both during and after installation. In general, this method of support cuts down shaft "lift" from casing heating to less than a quarter of the lift of foot-supported units.

Thus, unless casing temperatures are high, G-E standard turbines can be lined up cold with the assurance that shaft lift will be within allowable limits when the turbines are heated. No calculations or adjustments for setting the shaft low when cold will be required.

With the unit in line hot or cold, shaft whipping, which often causes bearing burn-outs, excessive vibration, and coupling wear is eliminated.

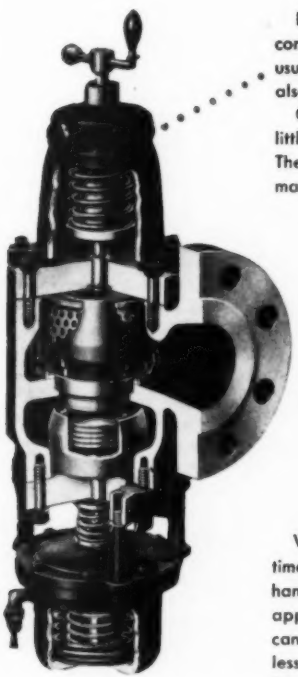
You save time when coupling the turbine to the driven unit, since the shaft height is identical on all G-E standard turbines. Not only that, but shaft diameter, keyway dimensions, etc., are identical on all turbine frame sizes. This standardization saves lost motion when installing or re-locating turbine drives.

INSTALLATION!

WITH GENERAL ELECTRIC STANDARD TURBINES

SAVING time when installing or re-locating turbines is one of the important advantages of using G-E standard turbines. Many other advantages: wider range governing, pressure lubrication, fewer wearing parts, are also standard with the Type DP —at no extra cost.

If you are planning installation of turbines, check with your G-E representative. He'll gladly give you application assistance and complete data. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*



Piping is simplified with G-E standard turbines. The combined trip-throttle valve—an exclusive G-E feature—usually makes a separate shut-off valve unnecessary. This also saves the cost of an extra valve.

Once installed, the combined trip-throttle valve requires little maintenance. There are no soft packings to replace. The steam strainer in the valve assembly is easily removed, made of Monel metal to resist corrosion.

With a new installation there's no need for you to spend time selecting spare parts it may be desirable to have on hand. This standard set of packaged spares contains parts applicable to DP turbines of all ratings. One set of spares can thus service several turbines. The price is very low—less than 25% of the price of a comparable set of spares for previous designs—thanks to standardization.

GENERAL ELECTRIC

PACKED with PERFORMANCE!

ROCKWOOD'S new ball type VALVE

Check for yourself these outstanding features that make the Rockwood Ball Type Valve the *best buy* in valves. Rockwood Valves already have proven to plant superintendents, engineers and maintenance men that they are easier to operate, last longer, give longer leak proof service — also increase the output of materials handled. Hundreds of these valves are now operating on pipe lines handling water, air, gas, solvents, acids, paints, varnishes, food, paper fluids, petroleums and many other liquids and gases.

Available in bronze with screwed ends in all pipe sizes from ½" to 2".

For more information, write for folder V-4.
Distributors in all principal cities.

• Quick opening and closing —

A quarter turn (90°) of the Rockwood Ball Valve control handle will give full opening to full closing. This same handle is designed so that it can be mounted in four different positions assuring clearance in all types of installations. It can also be removed and a "T" handle used wherever remote operation is necessary.

The fast, smooth, easy operating action of this handle will help speed up production and increase worker efficiency.

• Leak proof Service —

Every Rockwood Ball Valve is constructed with a floating bronze ball that is hard chromium plated, making it extremely resistant to pit,ing, scratching and abrasion. This ball in combination with the *resilient synthetic rubber seat* forms a tight seal when valve is in open or closed position. Rubber seat allows particles to be *automatically* wiped clear of seating surface when valve is opened or closed without injury to ball or seat.

Pressure of fluid stream automatically positions ball against rubber seat — prevents leakage.

• Full round flow —

The full round port area of the floating ball does not permit your fluid stream to change — creates no turbulence in the stream, thus friction loss is reduced to a minimum.

You get greater production at lower cost with the full round flow feature of the new Rockwood Valve.

RECOMMENDED FOR 300 P.S.I. WORKING PRESSURE.

ROCKWOOD SPRINKLER CO
102 HARLOW STREET WORCESTER 5, MASS

COST-REDUCING PERFORMANCE

for **Acids**

Exclusive features embodied in WILFLEY Acid Pumps help you make substantial savings in the cost of handling acids, corrosives, hot liquids or mild abrasives. WILFLEY pumps are trouble-free. They operate without attention. Production records of WILFLEY installations in today's most modern chemical plants prove the cost-saving dependability of these highly efficient pumps. 10- to 2,000-G.P.M. capacities; 15- to 150-ft. heads and higher. Individual engineering on every application. Write or wire for specific information.

A Companion to the Famous WILFLEY Sand Pump

•

Buy WILFLEY for Cost-Saving Performance

A. R. WILFLEY & SONS, INC., DENVER, COLORADO, U. S. A.

NEW YORK OFFICE: 1775 BROADWAY, NEW YORK CITY

WILFLEY *Acid* PUMPS

For high acetylene yield . . . specify National Carbide

produced under laboratory supervision

Rigidly controlled and tested during manufacture . . . and produced from the finest lime and coke available, "*National Carbide*" (meeting all Federal Specifications) assures every customer an exceptionally high acetylene yield per pound of carbide — a minimum 4½ cu. ft. This high quality, plus careful adherence to a special packaging technique accounts for "*National's*" wide acceptance as the Carbide producing maximum acetylene production . . . at lowest operating cost.

Also, and of vital importance to you, no matter where your plant is located, "*National Carbide*" can be obtained in any quantity from a nearby Airco office, authorized dealer, or warehouse.

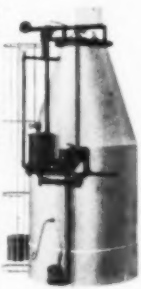
For more information about this top-grade product, write your name and address on the margin below, and send it to your nearest Airco office or authorized dealer for a copy of Catalog 30.

* * *

Air Reduction supplies Oxygen, Acetylene and other industrial gases . . . Carbide . . . and a complete line of gas cutting machines, gas welding apparatus and supplies, plus arc welders, electrodes and accessories. Ask us about anything pertaining to gas welding and cutting, and arc welding . . . we'll be glad to help you.

More news about AIRCO products

STATIONARY ACETYLENE GENERATORS



Airco's 300 pound (double rated — 600 cu. ft. per hr.) and 500 pound (double rated — 1,000 cu. ft. per hr.) stationary acetylene generators are suitable for operating all types of welding or cutting torches.

Automatic in principle, these generators feature hot galvanized shells — inside and out, with all welded seams. Operating parts have been reduced to a minimum — and are easily accessible for inspection or repair.

Also included as standard equipment are "protectomotor filters" to entrap suspended lime, and prevent clogging acetylene pipe lines, regulators and torches.

PORTABLE ACETYLENE GENERATORS

The Airco Type "P" portable acetylene generator is designed and constructed for efficiency, convenience, dependable and low-cost operation . . . and requires little attention other than draining and refilling with carbide and fresh water. Other features include:

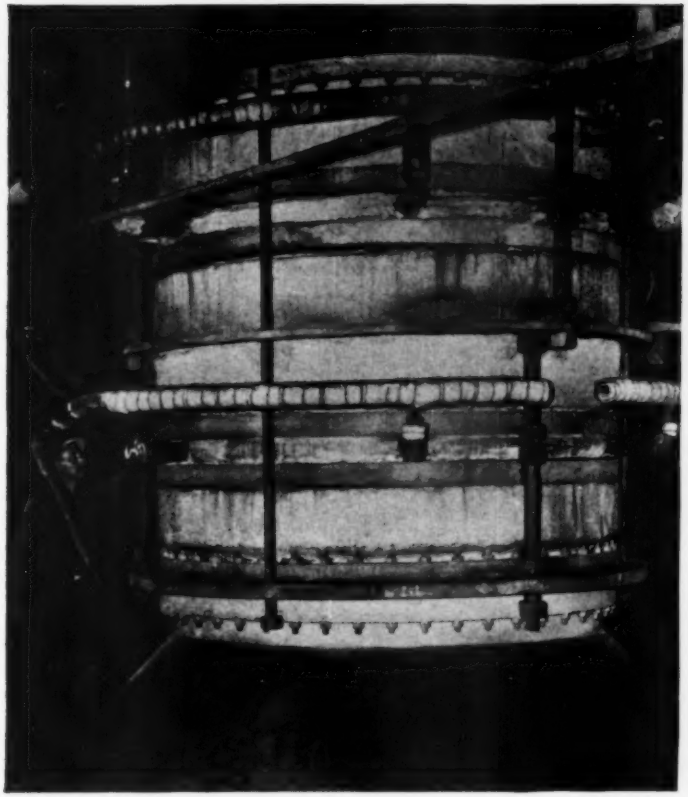
- **—Quick, easy charging**
- **—"Air Lift" principle of water circulation**
- **—Glass viewing window in carbide hopper**
- **—Simple and conveniently located controls**
- **—Large-size sludge agitator and valve for complete and fast sludge removal.**

Made in three sizes, each approved for double-rated operation: 15-lb. size, 30 cu. ft. per hr.; 30-lb. size, 60 cu. ft. per hr.; and 50-lb. size, 100 cu. ft. per hr.

All Airco generators conform with the specifications of Underwriters' Laboratories and Factory Mutual.

MAGNOLIA AIRCO GAS PRODUCTS CO.

Houston • Beaumont • Corpus Christi • Wichita Falls
El Paso • Fort Worth • San Antonio • Dallas



OIL-CRACKING HEAT AND CORROSION are not problems for ENDURO Stainless and Heat-Resisting Steels. Expansion joints, cracking stills and tubes, pumps, valves, sludge tanks, swing lines, heat exchanger and condenser tubes, vapor risers, still linings, bubble caps and trays—are *naturals* for ENDURO.

Enduro-THRIFTY METAL OF 10,000 USES

HIGH HEAT and CORROSION MEET THEIR MATCH

Heat that might wilt less sturdy materials and corrosive agents that might destroy find their match in Republic ENDURO Stainless and Heat-Resisting Steels. Even in the giant throat or expansion joint of cracking units, where both heat and corrosion are at their peak, ENDURO neither flinches nor weakens. Because of its high strength-to-weight ratio, lighter and more flexible construction also is possible.

ENDURO-made equipment can be counted on for fewer production interruptions and for substantially lengthened equipment life. While somewhat more expensive than less resistant materials, the initial cost is equalized by lower maintenance cost and higher continuous productivity. Its longer life makes it economical in the long run. It is the "thrifty" metal!

There are many ENDURO analyses, each designed to meet specific application needs. Talk with your equipment manufacturer or write for details to—

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

Export Department: Chrysler Building, New York 17, New York

Enduro **STAINLESS STEEL**

REG. U. S. PAT. OFF.

REPUBLIC STEEL

Check ALL 12 advantages: • RUST AND CORROSION-RESISTANCE • HEAT-RESISTANCE • HIGH MELTING POINT • LOW COEFFICIENT OF EXPANSION • HIGH STRENGTH • GOOD DIMENSIONAL STABILITY • NO METALLIC CONTAMINATION • EASY TO CLEAN • EASY TO FABRICATE • EYE APPEAL • LONG LIFE • LOW END COST

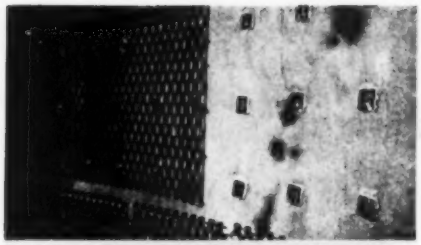
A. P. GREEN

SK-7 AND KS-4

TWO NEW REFRACTORY CASTABLES

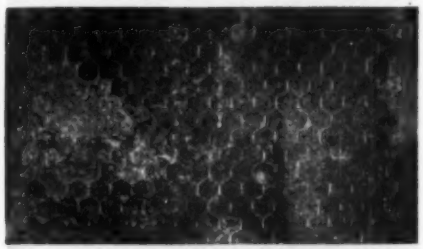
DESIGNED AND ENGINEERED FOR "GUN" APPLICATION

IN THE PETROLEUM FIELD



Application of SK-7 completed. Steel mesh attached to studs preparatory to shooting KAST-SET KS-4.

KAST-SET KS-4 being applied by means of a cement gun. Note steel mesh which anchors KAST-SET KS-4 and provides abrasion-resistant wearing surface for Catalytic Regenerator lining.



Interior of Catalytic Regenerator showing the completed lining with the KAST-SET KS-4 applied over the CASTABLE No. 20 SK-7.

CASTABLE No. 20 SK-7 — a lightweight insulating castable recommended for a service temperature of 1800° F., and KAST-SET KS-4 — a castable refractory with a top service temperature of 2750° F. were designed specifically, for cement gun application in the Petro-Chemical industry. This modern method of applying refractory castables greatly reduces labor costs. The A. P. Green Company, a leader in the development and manufacture of high quality castable refractories for normal pouring application, had the experience and engineering know-how necessary in producing these modern pneumatically applied castables.

Continued research, experimentation and improvement have resulted in the development of these gun-applicable refractory castables which afford the same trouble-free service obtained from A. P. Green mix and pour castables. They have gained wide acceptance in the petroleum industry and are specified by several large companies in that field. The outstanding advantages available through the use of SK-7 and KS-4 are:

1. Installation time and labor costs are reduced considerably, because these materials can be applied quickly.
2. Construction costs are held to a minimum as no forms are necessary.
3. These castables are adaptable to a variety of installations, particularly in places where normal pouring castables cannot be used.
4. The objectionable feature of many gun-applied materials (high rebound loss) has been corrected by the special compounding of these products.
5. Shooting a lining with SK-7 or KS-4 results in a finished installation having the balanced characteristics of a poured castable.

These materials were designed for use wherever castable refractories are required and in places where the use of normal pouring castables is impractical.

For detailed information concerning these castable refractories, write the Engineering Department of the A. P. Green Fire Brick Company — or call your local A. P. Green Distributor.

A. P. Green REFRACTORY PRODUCTS

A. P. GREEN FIRE BRICK COMPANY

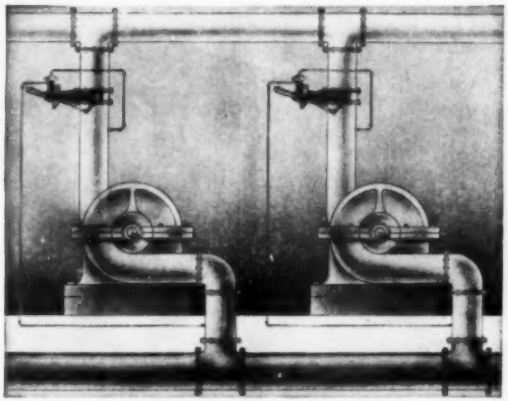
Mexico, Missouri, U. S. A.

A. P. GREEN FIRE BRICK CO., Ltd. in Canada

Representatives in the Principal Cities of the World

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



PROTECT PUMPING UNITS

The hydraulic cylinder controls in the above illustration of synchronous driven pumps are applied to R-S 125-pound Valves. If we assume 55 psi in the common header and a 2-pound lift, the cylinder positioners are set for 56 pounds. The valves will remain open as long as the differential remains above 56 pounds.

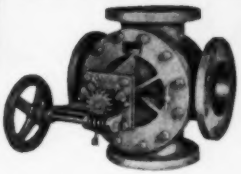
In the event of pump or power failure the natural reaction is for the flow to reverse itself through the pump. However, the drop in differential pressure causes the cylinders to close the valves and prevent reverse flow. Waterhammer is prevented because the valves close only as fast as the bleeding of the cylinder discharge. Similarly, when the motors are started the gradual opening of the valve vanes as pressure differential is regained prevents the pumps from developing an intolerable overload before full power is required.

Such automatic applications of R-S Valves are sensitive, simple and free from trouble. They definitely protect pumping units, prevent water hammer and reverse flow.

Consult with your local R-S representative. Look for the address and phone number listed under "R-S Products, Valves" or write direct.

R-S PRODUCTS CORPORATION
Wayne Junction • Philadelphia 44, Pa.

No. 731 60-inch R-S 30-pound Valve with 5-inch x 20-inch air cylinder positioner. Cylinder utilizes up to 100 psig operating air pressure. Positioner utilizes zero to 15 psig instrument air.



No. 648 8-inch R-S 125-pound 4-way Valve with heavy duty handwheel control and self-locking worm and gear. Widely used in lube-oil plants where sub-zero temperatures tend to freeze the ordinary 4-way valve and hinder its operation.

No. 752 20-inch x 12-inch R-S 150-pound Steel Off-center Relief Valve. The valve is pushed open by the diaphragm top and is closed by counter weights. Note positioner, handjack and exit cone on downstream side.

No. 641 14-inch R-S 600-pound Stainless Steel Valve with double-end shaft and dual finned stuffing boxes for elevated temperatures. Dual mounting brackets for mounting prime movers on either side of valve.

ATTENTION, NORDSTROM VALVE USERS:

LUBRICATE 1/10, 1/20, 1/50, 1/100 AS OFTEN

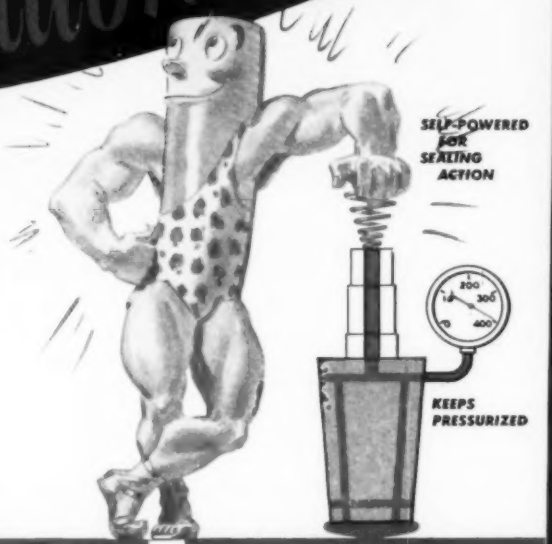
with Hypermatic

THE *miracle* LUBRICANT

Automatic lubrication—

SAVES MAN-HOURS, SAVES LUBRICANT

The immediate and eager acceptance of Rockwell Hypermatic lubricant has been phenomenal. Now, more than 5,000,000 Nordstrom valves can be automatically lubricated by changing to Hypermatic. There's nothing to purchase but the lubricant. Impressive savings in man-hours will be made in servicing your Nordstrom valves because Hypermatic works while your maintenance men are absent. It automatically force-feeds and seals any voids which would cause leakage. It stays energized for prolonged periods of time. Less lubricant is used because the valve is not over-lubricated but is fed the precise amount for perfect lubrication. In the event of an emergency closure the valve is always ready to be operated. The maintenance man will not have to stop and refill the chamber with lubricant before turning the plug. Hypermatic maintains automatic energized action as long as the pressure of the lubricant is above 50 lb.



NON-AUTOMATIC
Lubricated valve on line is pressurized to 1500 psi, using a non-automatic lubricant. Pressure gradually subsides and screw must be turned to re-pressurize.

HYPERMATIC
Identical lubricated valve on same line is pressurized to 1500 psi using Hypermatic energized lubricant. After 6 months, pressure has only slightly decreased.

THE SCAVENGER TEST

Inject Hypermatic in any Nordstrom valve. Then plug half open. Then scrape away all lubricant in the plug's exposed vertical groove. Close valve. Wait a few seconds. Then turn half open to expose grease in port. Presto—new lubricant has completely filled the groove.

Hypermatic IMPOUNDS POWER— like a door check

A self-closing door stores energy in the check body when you open door and uses this energy to close it. When you force in lubricant it causes Hypermatic to store energy for later use.

ROCKWELL Hypermatic

TRADE MARK

LUBRICANT

PATENTS APPLIED FOR

energizable

Buy it—Try it—Keep upkeep down

Immediate deliveries

Rockwell Hypermatic lubricant is available in the principal types for most services at normal temperatures. It comes in stick form and soft bulk. You may order through nearest distributing point or direct. Be sure to specify Hypermatic.

Genuinely automatic

Hypermatic is of itself automatic—not dependent upon pressure in the pipeline which can fail, or any mechanical contrivance. It stores its own energy.

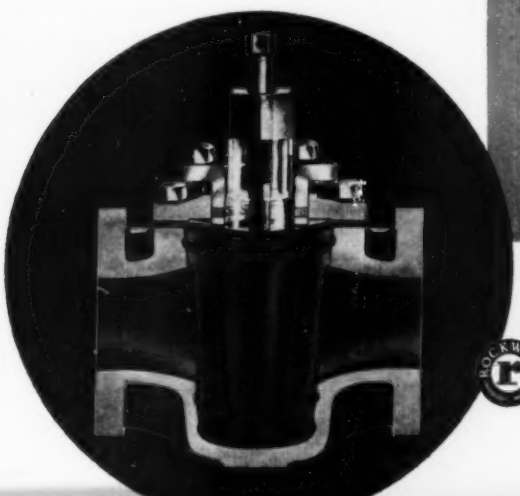
a hit!

Hypermatic seals instantly and keeps valves sealed

The reason there are over 5,000,000 Nordstrom valves in service is because they are the most dependable type of positive closure known to industry. Lubrication performs the triple function of lubricating the plug, sealing the ports and jacking the plug. Lubrication is the "making" of the valve. There's no substitute for lubricant. It's vital. Now, we have miraculously improved the lubricant by development of Hypermatic. Fundamentally, a valve is used to shut off a line. To do that, a valve must be in itself a perfect seal. Hypermatic, with its impounded energy, keeps the valve sealed.

Gives Nordstrom valves greater efficiency, longer life

Nordstrom put pressure lubrication into plug valves, permitting practical use of this type of valve in industry. Then "Sealdport" lubrication was added so that the ports were securely sealed on all sides. Then other major improvements were brought forth, such as the Hypreseal design, Merchrome coating, use of stainless steel and special alloys. NOW the greatest of valve advancements—Hypermatic automatic lubrication—gives to Nordstroms the effect of an improved design.



WHY PLUG VALVE LUBRICATION *is vitally essential*

1. ROTARY ACTION, MOST POSITIVE CONTROL

Simplest valve design is a tapered plug. When properly lapped and fitted, it forms a tight closure, but it must be lubricated to insure easy turning and tight sealing.

2. PLUG SURFACE SEATED ON LUBRICANT FILM

The Nordstrom valve employs pressurized lubrication which evenly distributes a film over the entire seating surface which is never exposed to the line. Easy turning is assured.

3. POSITIVE PRESSURE SEAL AROUND EACH PORT

Nordstrom "Sealdport" lubrication, by ingenious locating of connecting grooves in the plug and body, forms a pressure seal around each port which prevents internal and external leakage.

4. HYDRAULIC JACKING ACTION FREES PLUG

A few turns of the external lubricant screw regenerates pressure. If the plug is too tight to turn easily, a few extra turns of the screw hydraulically jacks the plug, freeing it.

5. HYPERMATIC LUBRICANT SELF-ENERGIZES FEED

As the "missing link" in perfect valve operation, Hypermatic lubricant now gives to Nordstrom valves automatic lubrication. Being self-energized by screwing down the lubricant screw, Hypermatic stores powerful energy to maintain constant feed indefinitely—for months in cases where valves are infrequently operated.

6. INSTANT CLOSURE IN EMERGENCY OR OTHERWISE

No longer is it necessary to refill an unserviced valve with lubricant before operation. By using Hypermatic, the valve is kept fully lubricated, ready to open or close instantly.

Greatly Multiplies Valve Life by Maintaining Valves in Fully Lubricated Condition—Saves Man-Hours

Nordstrom
LUBRICATED VALVES

NORDSTROM VALVE DIVISION—*Rockwell Manufacturing* Co.
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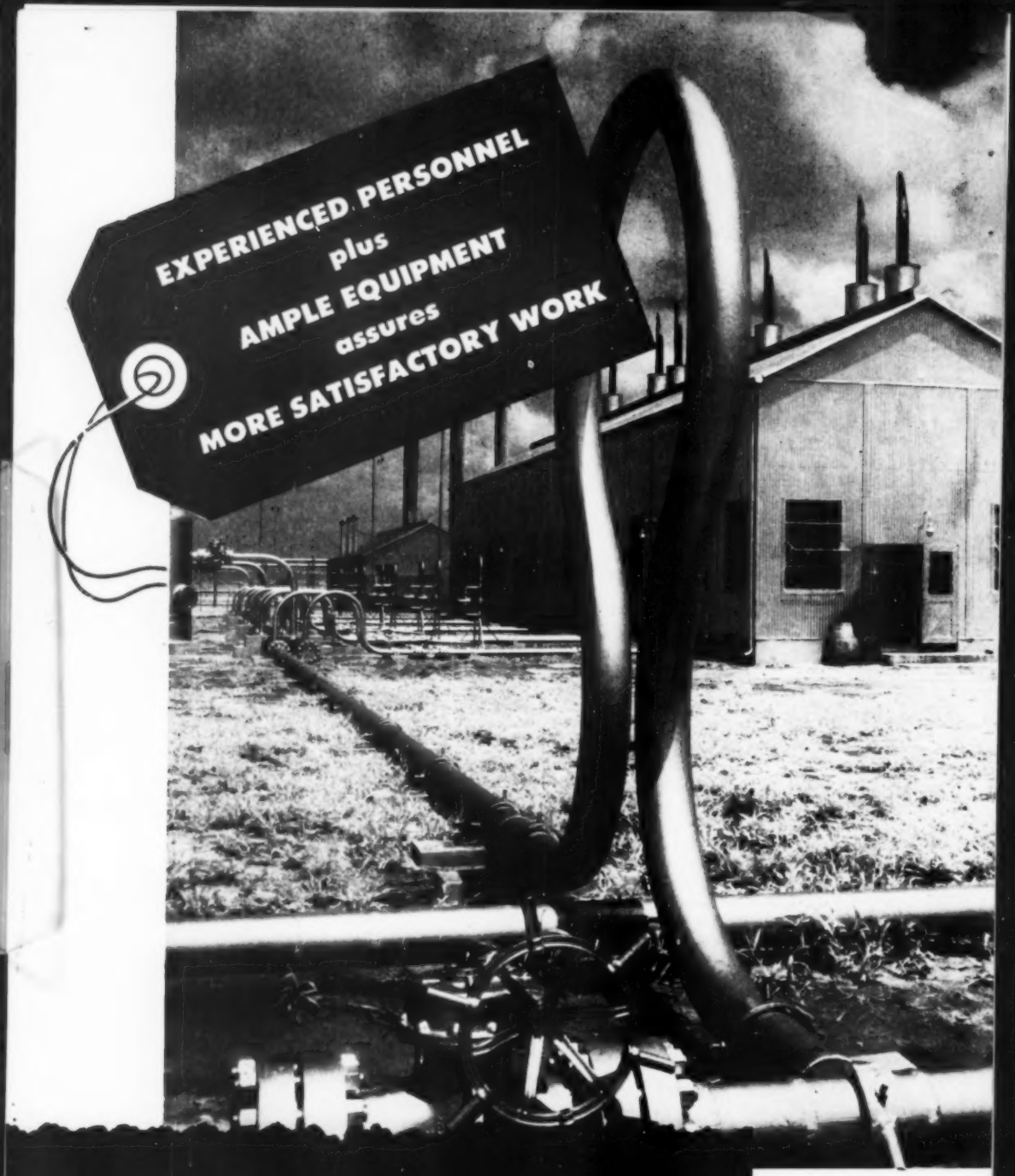

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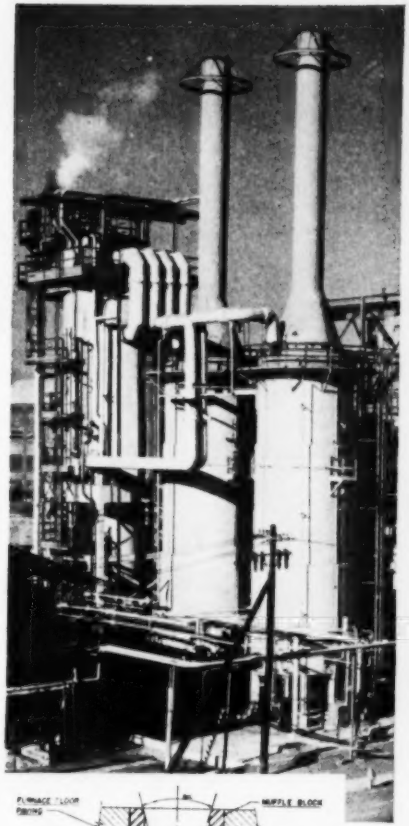
NATIONAL AIROIL FUEL OIL - GAS BURNERS

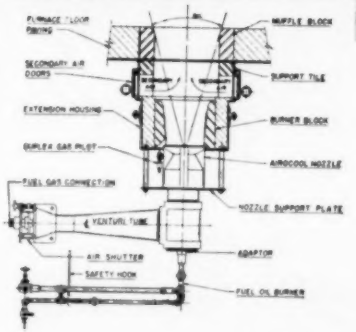
WIDELY USED THROUGHOUT INDUSTRY . . .

OIL-GAS TANDEM COMBUSTION UNITS

Yes, because of their extreme adaptability, "National Airoil" Vertical TANDEM COMBUSTION UNITS have been widely used throughout the petroleum industry. The TANDEM UNIT has a high turn-down ratio with a steady flame . . . maintains a high flame temperature with either fuel oil or gas; can be brought quickly to full capacity with a clean flame; and flame can be regulated and directed to uniformly radiate heat to the absorbing surfaces without impingement. The TANDEM COMBUSTION UNIT is also designed for firing horizontally, and for forced draft preheated air when necessary. It may also be applied to all types of boilers and process furnaces. Write for details about the TANDEM COMBUSTION UNIT and the various types available.

OIL BURNERS and **GAS BURNERS** for industrial power, process and heating purposes; **STEAM ATOMIZING OIL BURNERS; MOTOR-DRIVEN ROTARY OIL BURNERS; MECHANICAL PRESSURE ATOMIZING OIL BURNERS; LOW AIR PRESSURE OIL BURNERS; GAS BURNERS; COMBINATION GAS and OIL BURNERS; AUTOMATIC OIL BURNERS,** for small process furnaces and heating plants; **FUEL OIL HEATERS; FUEL OIL PUMPING and HEATING UNITS; FURNACE RELIEF DOORS; AIR INTAKE DOORS; OBSERVATION PORTS; SPECIAL REFRACTORY SHAPES.**





This diagrammatic drawing is of the National Airoil OIL-GAS TANDEM COMBUSTION UNIT (firing vertically upward) . . . widely used and popular in oil refineries throughout the nation.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: **1254 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.**
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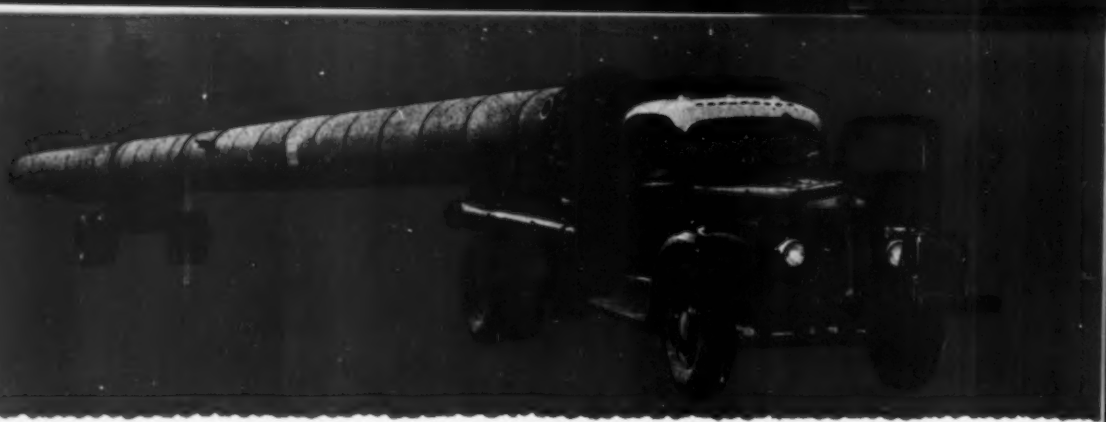
INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT



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OF ANY SIZE AND DESIGN

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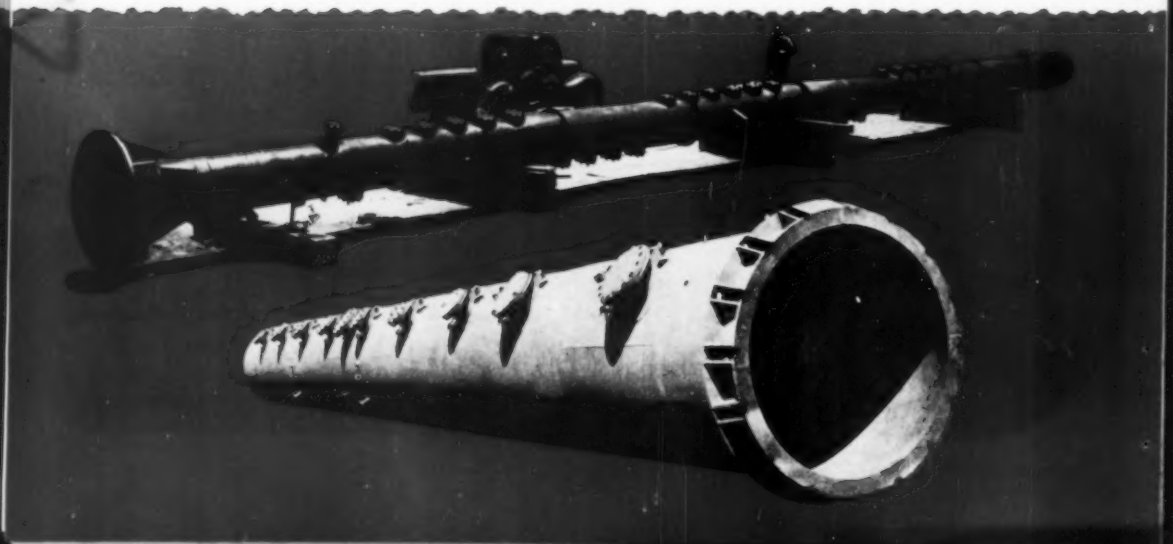
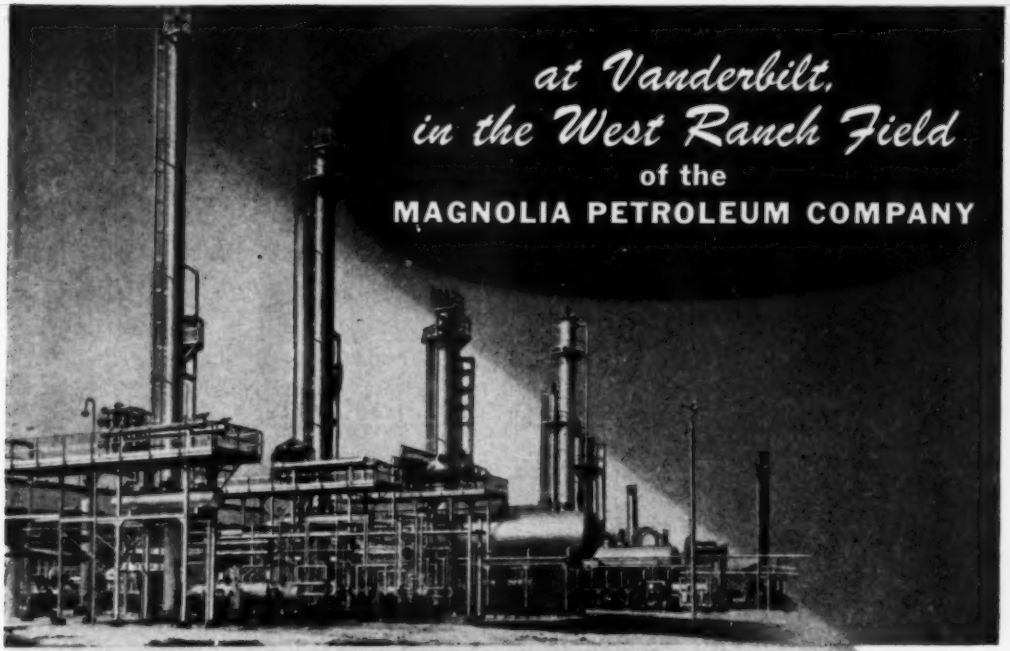
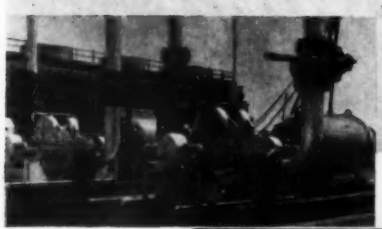


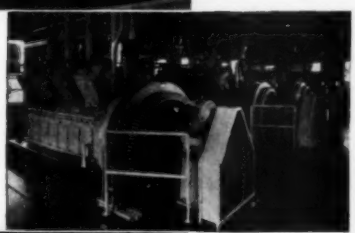


at Vanderbilt, in the West Ranch Field
of the
MAGNOLIA PETROLEUM COMPANY

THERE'S MORE THAN MEETS THE EYE



Left: These two Type CNT pumps circulate lean oil to three absorbers and one reabsorber.



Right: Natural gas brought into the plant provides fuel for driving these four Ingersoll-Rand 4-cycle V-angle generator units.

Left: The finished products at Vanderbilt are handled by this array of I-R "Motorpumps."

Under the maze of piping and processing units of the recently completed Vanderbilt natural-gasoline extraction plant, *Ingersoll-Rand pumps and gas engines play a vital role.*

The daily processing of 40,000 gallons of liquid hydrocarbons requires many types of pumps. Here, at Vanderbilt, the major portion of the centrifugal pumping assignment—from circulating cooling water to delivering the finished products to tank cars and trucks for shipment—bears the Ingersoll-Rand name.

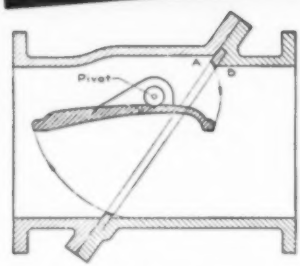
Power for driving the pumps, cooling-tower fans, for lighting the plant, and for home use of the operating personnel is generated by four 375-kva generators each driven by an Ingersoll-Rand Type PVG, 4-cycle V-angle gas engine.

Yes, at Vanderbilt—as in so many other important industries—Ingersoll-Rand equipment plays a vital role.

336-14

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.
COMPRESSORS · AIR TOOLS · ROCK DRILLS · TURBO BLOWERS · CONDENSERS · CENTRIFUGAL PUMPS · OIL AND GAS ENGINES

THERE IS *No Slamming* WITH CHAPMAN TILTING DISC CHECK VALVES



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

BECAUSE of the design of the balanced hinge-pinned disc, Chapman Tilting Disc Check Valves always close smoothly and quietly. There is no slamming, no hammering, no destructive pipe-line stress.

When open, the disc rides smoothly in the flow. As it closes, the effect of the stream on the short flap cushions the contact with the body seat. There is no sliding action and therefore wear on seats is reduced to a minimum. In addition, head losses are lowered as much as 65% to 80% over those experienced with conventional type check valves.

Available in either iron or steel.

The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASS.

SMALL TRAP

BIG *Performance*

Little? Sure. But what a giant's job they do!

That's how petroleum men judge Yarway Impulse Steam Traps.

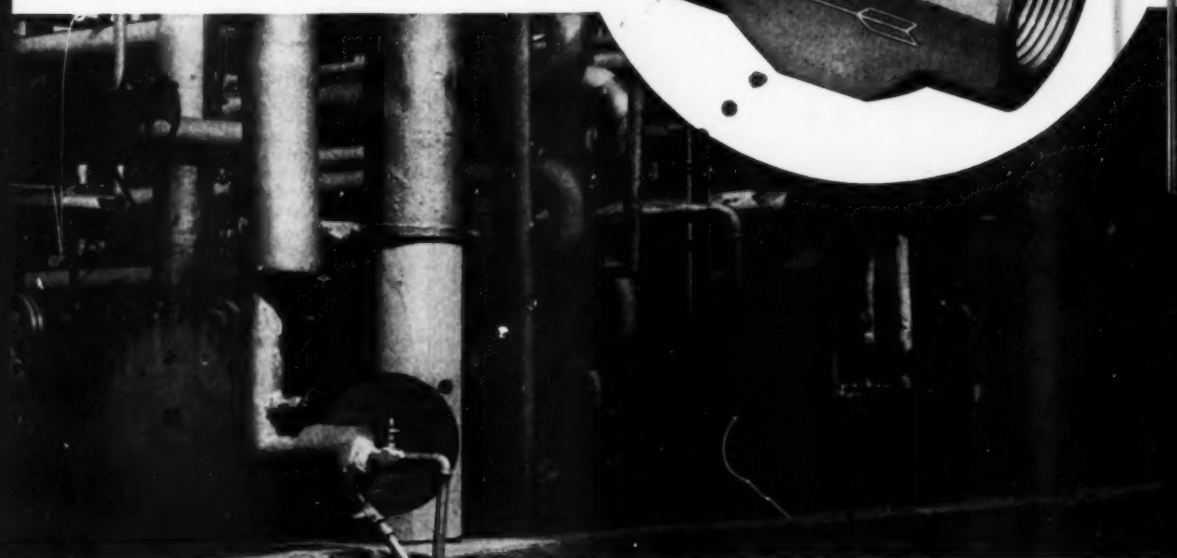
Yarways are well suited for refinery work. The small size itself is an important feature. They are easy to install, fit in anywhere, require no special supports.

In service they *drink* condensate, discharging *continuously* on heavy loads, at short *intervals* on light loads—providing maximum heat in the shortest time, and keeping equipment at top efficiency.

Yarways are suitable for all pressures without change of valve or seat. Simplicity of construction (only one moving part) minimizes maintenance. Also, initial cost is low.

Try some Yarways today—standardize on them tomorrow. See your nearest Supply House or write for Yarway Bulletin T-1739.

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.



YARWAY IMPULSE STEAM TRAP

Farm Bureau to Install Fluid Cat Cracking Unit

By R. J. Potts

Superintendent, Refinery Division, Indiana Farm Bureau Cooperative Association, Inc.

THE installation of a UOP Improved Fluid Catalytic Cracking Unit which is planned for our refinery at Mount Vernon, Ind., is a major step in a continuing program pointed toward increased capacity and improved operating efficiency.

R. J. Potts

We believe that our new cat cracker, together with other improvements which we have contemplated, will place us in a better position than ever before to perform our function, which is to supply adequately the continuously growing number of our customers with high quality gasoline and other petroleum products.

Plan for the Future

Our plans do not stop with producing gasoline to meet today's—or tomorrow's—standards. We are looking far into the future. The trend of automotive engine design today points to steadily increasing compression ratios which will require motor fuel of higher octane rating than the premium gasoline of today and the improvements now planned will enable us to keep step with the advancing "march of the octanes" for years to come. It is expected that with the aid of the new facilities, of which the cat cracker will be the key, the refinery will produce about 71% of gasoline, based on crude. With three cc of tetraethyl lead, approximately 40% of this gasoline will have 94 octane rating, and the remainder 86 octane (Motor Method).

When the new operation is in effect, running our present daily capacity of 8,000 barrels of Illinois Basin crude, yields of products are expected to be as follows:

	Barrels
Gasoline (including poly)	5,660
Kerosene	400
No. 6 Fuel Oil	1,540
Butane	120

In addition, the production of fuel gas will be sufficient to develop 116,000,000 Btu per hour, enough to supply the fuel needs of the plant.

Cat Cracker Has Single Column

The cat cracker will have the reactor and regenerator housed in a single column. Its design capacity will be 3,640 b/d at 55% conversion which is more than one and one-half times the original crude capacity of our refinery. A saving will be effected through omitting the flue gas waste heat boiler which is usually a part of the UOP design.

(Advertisement)

The boiler is unnecessary at present because of the large quantity of gas available for fuel.

The cat cracker and other new facilities will be designed and engineered by Universal and built by our own refinery forces.

Other Equipment

The current project includes, in addition to the cat cracker, a new vacuum unit and a gas concentration system. Design capacity of the former will be 3,200 b/d of reduced crude. Its function is to produce vacuum gas oil as charge to the cat cracker.

The gas concentration unit is a three-column system designed to recover approximately 75% of the propane and over 95% of the butane from the gas. It will include a reboiler stripper for removing the H_2S from the gas to be charged to the UOP catalytic polymerization unit, which is a part of our existing plant. This unit is producing 120 b/d of 82 octane polymer and will be enlarged to handle the increased volume of cracked gas and to produce about 300 barrels of polymer daily.

When market conditions warrant, bottled gas, or LPG, can be produced with only minor changes.

The UOP 2-coil thermal cracking unit, which also is a part of our existing plant, will be operated to the best advantage as an adjunct to the cat cracker. The capacity of the thermal cracker was recently enlarged for this purpose by the addition of a second reaction chamber. This added about 300 b/d to its capacity.

The catalytic cycle stock, together with vacuum bottoms and miscellaneous virgin stocks, totalling about 2,760 b/d, will be processed in the thermal cracker, which is flexible enough to permit the cracking of kerosene.

While some existing elements will be used, most of the equipment will be new, purchased by the Franklin Supply Company, Chicago.

Built in 1940

The 10-year history of our refinery has been a record of consistent progress. It was built from the ground up, in 1940, by our Association, to process crude from the nearby Griffith pool and supply Farm Bureau members in Indiana with gasoline and other petroleum products. The original plant consisted of a 2,000 b/d skimming unit.

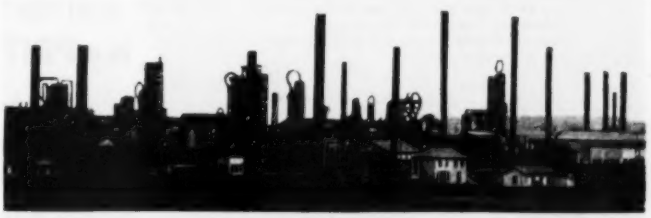
As motor fuel consumption and octane requirements steadily increased, it became necessary for us to produce more and better gasoline. To this end we started construction of the thermal cracking unit above referred to which went into operation in June, 1946.

The next step was the installation of the modern 8,000-barrel crude unit placed in operation in September, 1948.

Today the plant is running four times as much crude as its original capacity and producing gasoline and other products of a quality impossible to achieve when the original refinery was built.

(Advertisement)

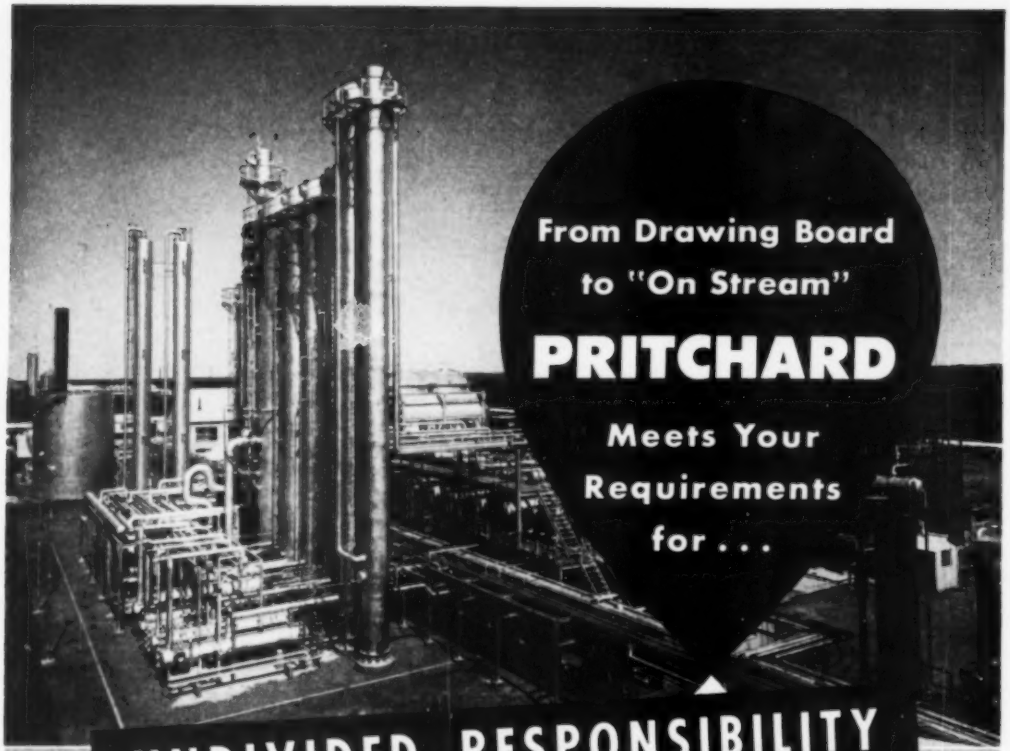
A MAJOR FORCE BEHIND EFFICIENT REFINERY DESIGN, OPERATION AND MAINTENANCE



UNIVERSAL OIL PRODUCTS COMPANY

UOP General Offices: 310 S. MICHIGAN AVE., CHICAGO 4, ILLINOIS, U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery



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to "On Stream"

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Photo above shows a recently completed Natural Gas Dehydration and Gasoline Recovery Plant which was designed, engineered and constructed by Pritchard. It has a capacity of 140,000,000 SCF per day Natural Gas Dehydration, 90,000,000 SCF per day National Gasoline Recovery, 110,000 gallons per day total products.

THREE FUNCTIONS — Engineering, Construction, Manufacturing

IN FIVE FIELDS — Serving the CHEMICAL, POWER, PETROLEUM and GAS industries as well as providing specialized EQUIPMENT for all industries.

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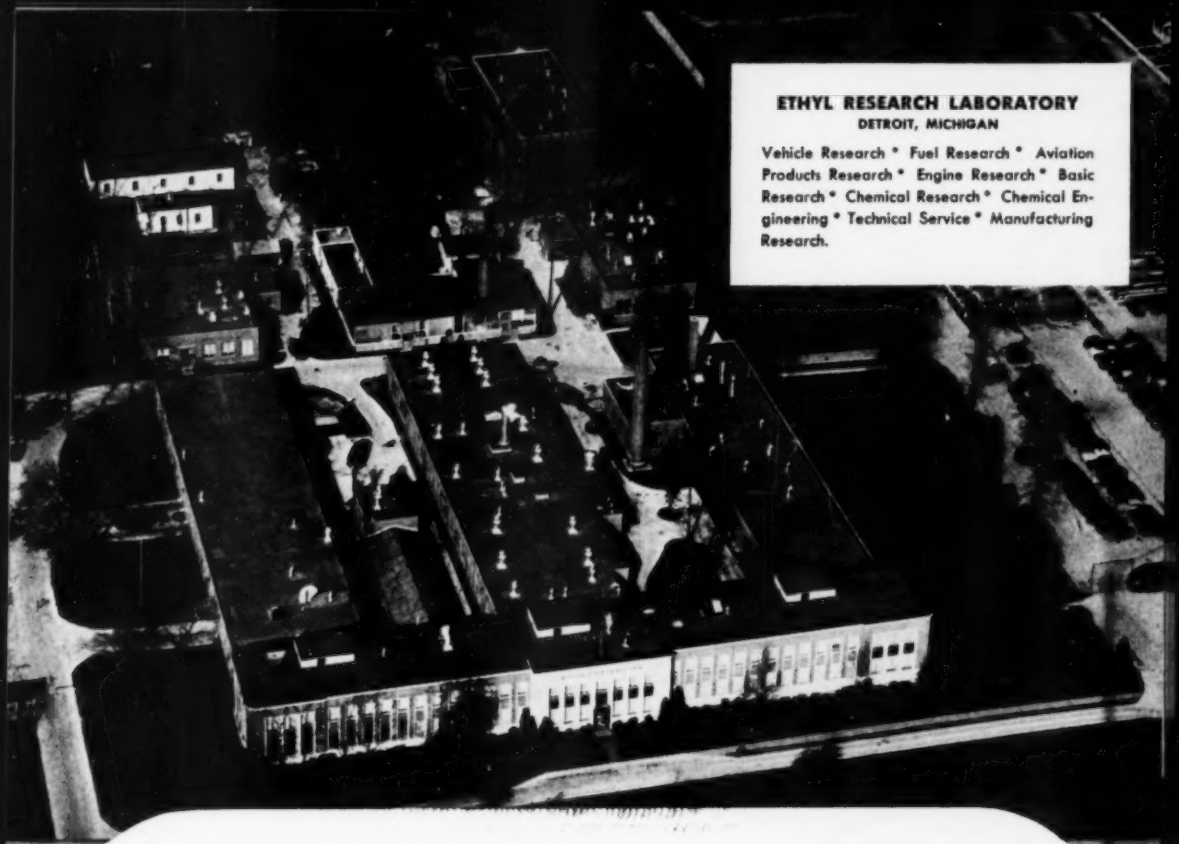


ETHYL RESEARCH LABORATORY
DETROIT, MICHIGAN

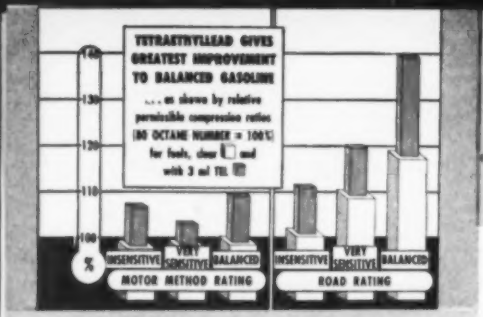
Vehicle Research * Fuel Research * Aviation Products Research * Engine Research * Basic Research * Chemical Research * Chemical Engineering * Technical Service * Manufacturing Research.

One Research Laboratory Working for Many

GASOLINE is produced by many types of companies having varied operations and interests. Some companies manufacture it from crude oil; others recover it from natural gas. For one group it is the major product; for a second group it is less important than other products. One refiner markets on a national scale; another supplies a more limited area. Every one of these companies is important—an essential element in the Oil Industry, which makes gasoline available to the public through thousands of outlets.

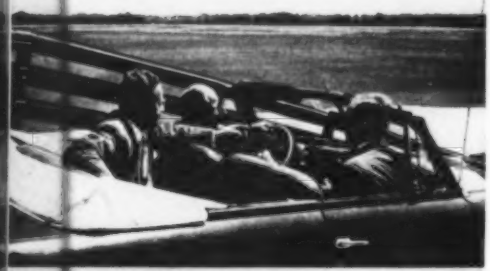
Regardless of the nature of a refiner's operations, Ethyl's research and technical service program is designed to assist him in the economical production of gasoline to meet today's and tomorrow's requirements. In the aggregate, this program is intended to serve those interests which all refiners have in common, but in addition it is planned to contribute to the solution of the technical problems of individual refiners.

THE FOLLOWING THREE PAGES SHOW HOW ETHYL RESEARCH SERVES ALL TYPES OF REFINERS

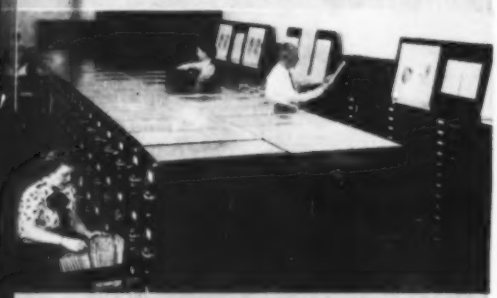


BUILDING BETTER FUELS

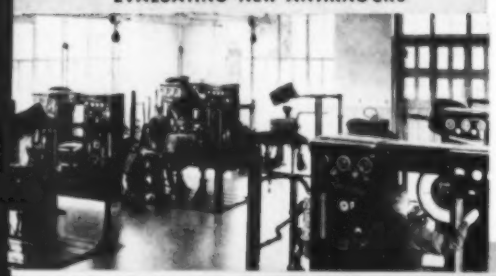
APPRAISING NEW FUELS



REFINERY-AUTOMOTIVE LIAISON



SUPPLYING TECHNICAL DATA
EVALUATING NEW ANTIKNOCKS



ETHYL SERVES

Refiners with Limited Research Facilities are Benefited by these Ethyl Services

1. Indicating Patterns of Fuel Composition

Extensive research on fuel-engine relationships enable Ethyl to indicate general patterns of refinery processing which yield gasolines having good response to tetraethyllead and high antiknock performance in service. Antiknock quality is important but it is not the only requirement of good gasoline. For example, fuels may form combustion products which interfere with normal engine operation. Ethyl passes along to refiners data from its research relating to cleanliness of fuel burning, volatility, sulfur effects, and other properties.

2. Evaluating Experimental Gasolines

As engine design has advanced, the Motor and Research methods of knock rating have become less reliable indices of the antiknock performance of fuels in automobiles. As a consequence, a complete antiknock evaluation of experimental fuels produced by a change in refinery operations must include tests in automobiles or in special laboratory engines.

In appraising experimental fuels Ethyl works closely with engine manufacturers and is able to choose a limited number of vehicles in which knocking is representative of current engines. Ethyl suggests broadly the composition of better gasolines that may be produced economically, and makes evaluations of experimental fuels produced by refiners during studies of proposed changes in their operations.

3. Interpreting the Viewpoints of Refiners

Automotive manufacturers in an earlier period did not find it necessary to be concerned about the specifications of gasoline, and the oil companies had limited interest in the engineering of automobiles. In those days volatility was a more important property of gasoline than antiknock quality.

Today the problems of the two industries are inseparably interwoven. Refiners with large research laboratories have close contacts with engineers of automotive companies. It is equally important that problems and operations of oil companies without extensive laboratories be understood by automotive manufacturers. To many refiners Ethyl's presentation of technical problems represents a real service.

4. Supplying Well-Rounded Technical Information

Ethyl's research program is concerned with the development and manufacture of antiknocks, the refining and use of gasolines, and the design and operation of engines.

Because of this program, and the 26 years of close relations with the oil and automotive industries, Ethyl uniquely serves refiners by providing complete technical service. Thus refiners with limited research facilities are served every day by the 482 employees in Ethyl's Laboratories.

THE REFINER

Refiners with Extensive Research Facilities are Supported by these Ethyl Services

1. Explaining Fuel Performance by Basic Research

Fundamental knowledge of antiknock action is best gained by the study of individual hydrocarbons in special single-cylinder engines and other experimental equipment under closely controlled conditions. This serves as a background for the study of composite fuels in engines. Such research, sponsored by Ethyl in its own laboratories and in universities, contributes to an understanding of more complex fuel-engine relationships and adds to the foundation on which refiners build their fuel research programs.

2. Improving Fuels by Applying Basic Knowledge

When burned in engines, gasoline is affected by a host of variables uniting in different combinations with changes in engine operation. Ethyl's extensive data on the knocking of individual hydrocarbons and composite fuels in single-cylinder engines provides a background for explanation of the knocking pattern of commercial gasolines and indicates fuel properties that will be advantageous in the future.

Ethyl cooperates with oil companies in the application of this knowledge to their individual operations. This involves evaluation of experimental gasolines in specially equipped cars and rating of the gasolines in laboratory engines designed to simulate the operation of automobiles.

3. Exchanging Information with Oil Companies

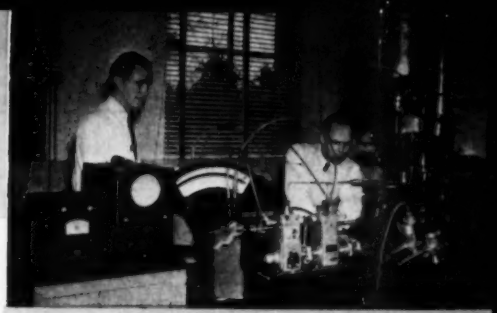
Technical liaison is maintained with refiners through frequent discussions by Ethyl personnel with representatives of oil companies at their offices and laboratories. The interrelated problems of fuels, crankcase lubricants, and engines are so numerous and complex that it is advantageous to hold periodic forums in which groups of technical people from an oil company and from Ethyl discuss common problems. These joint technical conferences contribute to broader technical understanding and permit Ethyl to relate its technical activities more closely to the problems of oil companies.

4. Developing Methods and Equipment

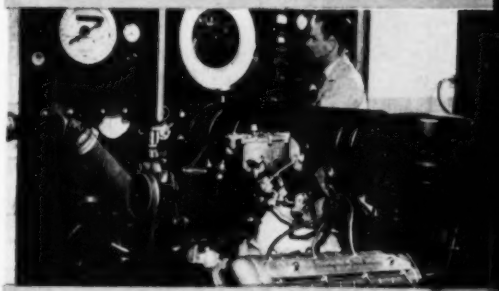
Progress in the development of petroleum products requires continuous improvement in experimental equipment and procedures for determination of the complex relationships between gasolines, lubricating oils, and engines. Much of the program of the Ethyl Laboratories is devoted to the development of special equipment and techniques aimed at increasing the significance of laboratory data in respect to the performance of automotive petroleum products in service.

Ethyl is glad to pass along to its customers the details of these developments and the results of its experience in the design and operation of its research laboratories.

See next page for more Ethyl Services to refiners

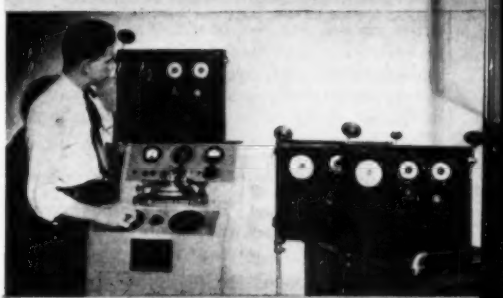


EXPLAINING FUEL PERFORMANCE



APPLYING BASIC RESEARCH

TECHNICAL CONFERENCE



NEW METHODS AND EQUIPMENT

RESEARCH ON HYDROCARBONS

Ethyl Technical Activities Serve All Refiners

1. Improving "Ethyl" Antiknock Fluids

For more than 26 years Ethyl has conducted continuous and intensive research to improve the quality and reduce the cost of "Ethyl" antiknock compounds. Seven new and better antiknock fluids for motor gasolines have resulted in a substantial reduction in formulation cost which, along with savings in manufacture, has been reflected in lower prices to the oil industry.

2. Preventing Engine-Fuel Problems

After gasoline has been made, it must operate satisfactorily in many types of engines. Working with the manufacturers, the Ethyl Laboratories make every effort to help correct, before production, any features of engine design not likely to be compatible with the products offered by refiners.

3. Creating Mechanical Octane Numbers

Convinced that Ethyl's interests are inseparable from those of its customers, the Laboratories render an indirect but important service to oil companies by developing features of engine design which improve power and economy without requiring higher antiknock quality. Work is done on improvement of combustion chambers, and manufacturers are assisted in the development of intake manifolds which provide faster warm-up and better distribution of fuel to the cylinders.

4. Multiplying the Benefits of Research

The value of information developed by research is not lost through usage, but becomes more valuable as more people employ it. Without Ethyl's broad research program, individual oil companies might find it necessary to carry on many of the expensive research services now conducted by Ethyl.

It is Ethyl's objective to have its research program ensure that the addition of "Ethyl" antiknock fluids to refiners' gasolines will give the maximum improvement in quality, and that the resulting fuel will give the most satisfactory performance in service.

SINCE 1923 — *Continuous Research to Provide Better Antiknock Service*

ETHYL CORPORATION

RESEARCH LABORATORIES

DETROIT, MICHIGAN . . . 1600 WEST EIGHT MILE ROAD

SAN BERNARDINO, CALIFORNIA . . . 2600 CAJON ROAD

"SAVES 2000 LBS. STEAM PER HOUR"

with Taylor Compressor Control

One of the largest refineries in the country reports that Taylor automatic compressor control with Speed Transmitter has saved them as much as 2000 lbs. steam per hour per compressor in the past year. It can do much the same for you.

Like all other process industries, for many years this refinery held compressor speeds within certain limits by manually adjusted governors—regardless of changes in process conditions.

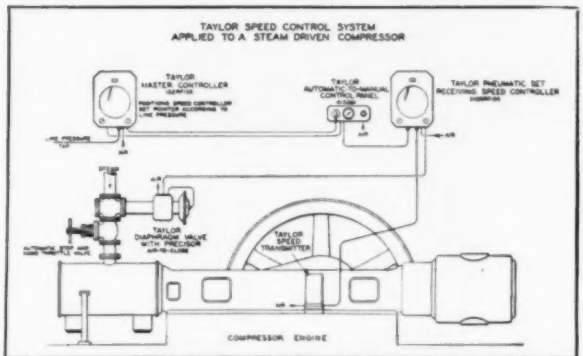
Now in the face of today's more rigid processing requirements, Taylor Compressor Control Systems combined with Speed Transmitters give you fully automatic control of compressors with direct relation to other variables in your process. These new compressor control systems were developed by Taylor Engineers working hand in hand for years with leading compressor manufacturers.

This all adds up to one important point. **When a compressor's function is closely controlled according to process requirements, substantial economies result from reduced fuel consumption as well as higher yields of quality end product.**

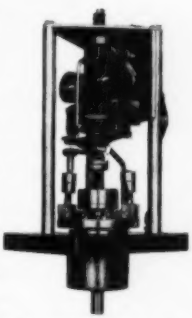
We can furnish a rugged, dependable control system for any type of drive. Ask your Taylor Field Engineer! Or write Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

• • •

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.



HERE'S HOW THE SPEED TRANSMITTER WORKS



Briefly, it's a dependable pneumatic force-balance instrument. Principal parts: drive shaft, rotating table, flyweights and pneumatic force-balance assembly. The full range of engine speed causes but slight change in the radial position of flyweights to effect full output air pressure change. Since radius is essentially constant, centrifugal force of flyweights increases as the square of the speed. Consequently the air pressure to the force-balance bellows and the receiver Speed Controller must vary as the square of the speed. Drawing above shows how Speed Transmitter teams up with Taylor Pressure Controller, Pneumatic Set Speed Controller and diaphragm control motor to maintain constant discharge pressure from a compressor on a process.

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

The ship that helps create jobs in Alaska

From Ketchikan on up the coast . . . in dozens of towns and cities in Alaska . . . people greet the tanker "M. S. Alaska Standard" with considerable affection. For, over the years, she's helped Alaskans develop thousands of jobs.

Regularly she loads a full cargo of petroleum products and takes them wherever they're needed . . . like some giant floating service station. She pokes her prow into rocky inlets to serve fish canneries, goes on up the coast a few miles to bring a new mine the lubricants it needs to work, stocks oil for fishermen so they no longer have to travel six or seven hundred miles to refuel when the salmon run is on.

In short, she helps both the coast and interior of Alaska develop its resources . . . just as the oil industry throughout all our country helps other industries grow and people work, produce and prosper.

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

POWELL makes a *Complete* Line of Valves for the Process Industries

For more than twenty-five years Powell has been specializing in valves for the Process Industries. Whenever a new process has been installed, Powell has been ready with the right valves to meet all of its requirements.

Today the Powell Line for the Process Industries is so *complete** that there are Powell Valves specifically designed to meet the requirements of each and every flow control service in *your* industry. And if you install the *right* valves to meet individual service conditions, you can be assured of maximum performance. *To be sure* you have the right valves, consult Powell Engineers.

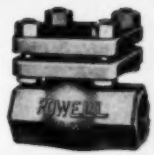


Fig. 2004—300-pound Stainless Steel Lift Check Valve with bolted cap.

Fig. 3063—Class 300-pound Cast Steel Angle Valve with a top-mounted, fully enclosed explosion proof electric motor operator for quick positive opening and closing.

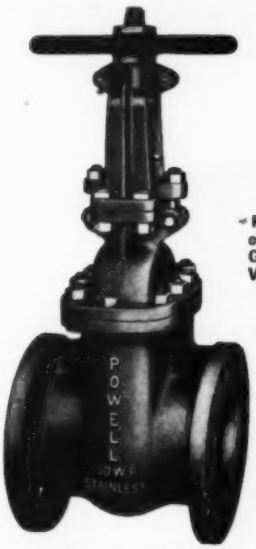


Fig. 2453-G—Large 150-pound Stainless Steel Gate Valve with bolted flanged yoke-bonnet, outside screw rising stem and tapered solid wedge. Made in sizes 5" to 30", inclusive.

THESE ARE A FEW OF THE MANY POWELL VALVES YOU WILL SEE AT OUR

BOOTH 54

22nd Exposition of Chemical Industries
Grand Central Palace, New York City
November 28 to December 3

* Powell Valves are made in Bronze, Iron, Steel and a wide selection of Corrosion-Resistant metals and alloys. Valves of every type—Globe, Angle, Gate, Check, Non-return and Flush Bottom Tank Valves—are included in the Complete Powell Line.

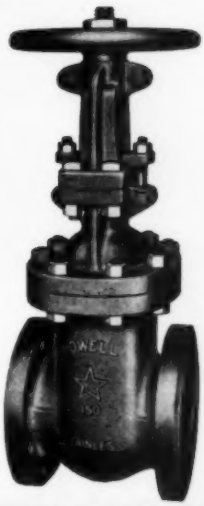


Fig. 1503 S. S.—Class 150-pound Stainless Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke and tapered solid wedge.

Fig. 1973—Small 600-pound Stainless Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke, tapered solid wedge. Sizes ½" to 2", incl.

The Wm. Powell Company
Cincinnati 22, Ohio
DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

CUT MAINTENANCE COSTS
in these process groups
Oil Distillation
Thermal Conversion
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Desalting, Filtration, and Acid Treating
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Refinery Tubing
A wide choice of analyses for extremes of pressure, temperature, corrosion, and oxidation
Carbon Steel (½% Mo)
Carbon Moly Steel (½% Cr, ½% Mo)
Croloy ½ (1¼% Cr, ½% Mo,
Croloy 1¼ (2% Cr, ½% Mo)
Croloy 2 (2¼% Cr, 1% Mo)
Croloy 2¼ (3% Cr, 1% Mo)
Croloy 3-M (5% Cr, ½% Mo)
Croloy 5 (5% Cr, ½% Mo,
Croloy 5-Si 1½% Si)
Croloy 5-Ti (5% Cr, ½% Mo, ½% Ti)
Croloy 7 (7% Cr, ½% Mo)
Croloy 9-M (9% Cr, 1% Mo)
Croloy 18-8-S (18% Cr, 8% Ni)
Croloy 16-13-3 (16% Cr, 13% Ni, 3% Mo)
Croloy 25-20 (25% Cr, 20% Ni)
Latest detailed information on all B&W Refinery Tubing is contained in Technical Bulletin 6-E.
B&W SEAMLESS and WELDED TUBES
THE BABCOCK & WILCOX TUBE COMPANY

"A Cottrell Installed by Research Corporation *will reduce catalyst loss to less than one ton per day"*

The through-put capacity of the cracking unit in the oil refinery was 20,000 barrels per day. The engineer from Research Corporation noted the plant arrangement and type of catalyst to be used and was able to recommend a Research Corporation Cottrell that would keep catalyst losses to less than one ton per day. Actually in some plants the Cottrells have, in effecting the above results, recovered as high as 50 to 100 tons of catalyst per day.

Performance like this is the result of over 35 years of experience combined with careful engineering appraisal, attention to details and a remarkably efficient method. These, combined with equipment which gives recoveries of over 99%, are responsible for outstanding records of recovery.

A letter from you to the Research Corporation will bring an informative bulletin describing HOW the Research Corporation Cottrell Electrical Precipitator performs, and HOW it can bring about important savings. Write for your copy today. BC-107

Research Corporation Installations

47 CARBON BLACK PLANTS
200 METALLURGICAL INSTALLATIONS
203 ACID PLANTS • 34 PAPER MILLS
262 DETARRING INSTALLATIONS
195 POWER STATIONS
71 STEEL PLANTS • 95 OIL REFINERIES
AND MISCELLANEOUS INSTALLATIONS

RESEARCH CORPORATION

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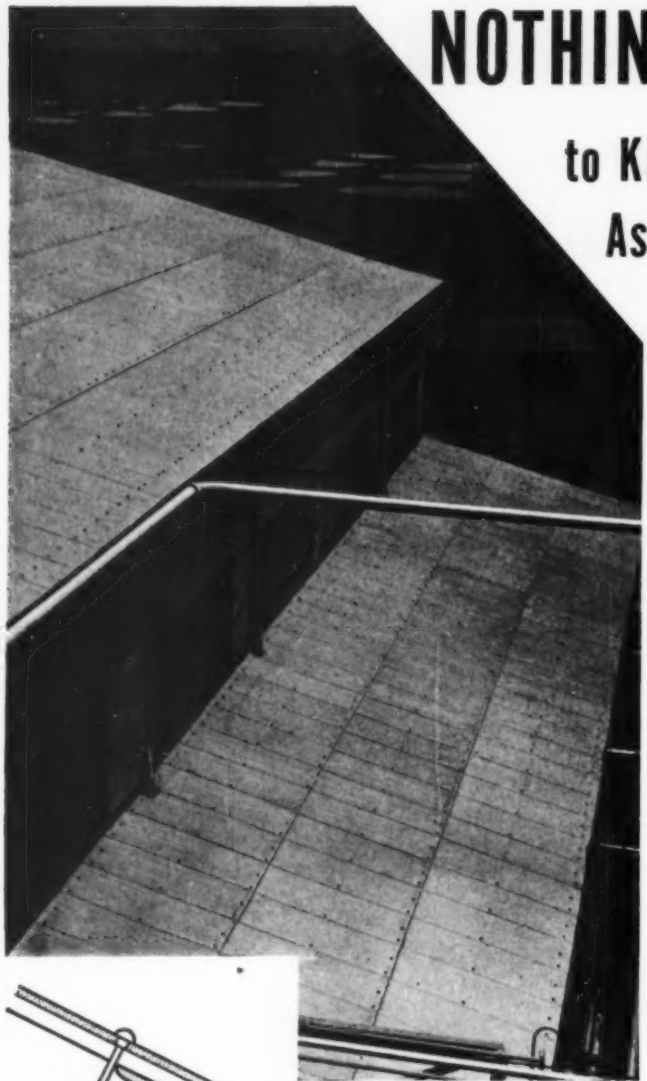
NOTHING HAPPENS

to K&M *"Century"* Asbestos Corrugated



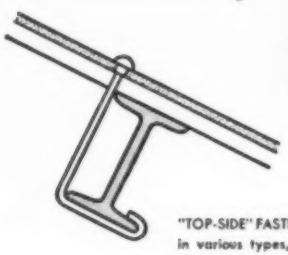
Here you see it used for both the roofing and siding on this Shell Oil Company building at Deer Park, Texas. Don't ever expect to see it hurt by the weather or other adverse atmospheric conditions. Count on it to go rustless and rotless. It won't suffer from rodents and termites, and is exceptionally resistant to fire.

Easily cut and fitted on the job, K&M "Century" Asbestos Corrugated produces tight, good-looking surfaces at minimum labor cost. For extra savings use "TOP-SIDE"* fasteners, as on this Shell building. They entirely eliminate scaffolding and are only available with K&M "Century" Asbestos Corrugated.

Your finished job will benefit by the inherent structural strength of this material which actually gains strength with age. As for upkeep, you needn't figure on even one bit of paint!

*U. H. & B. Enterprise Corp.

ERECTORS: Lummus Co., New York City.



"TOP-SIDE" FASTENERS are made in various types, to fit all steel members on both roofing and siding. Illustration of typical "J" type for roofing.

Nature made Asbestos...
Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos

KEASBEY & MATTISON
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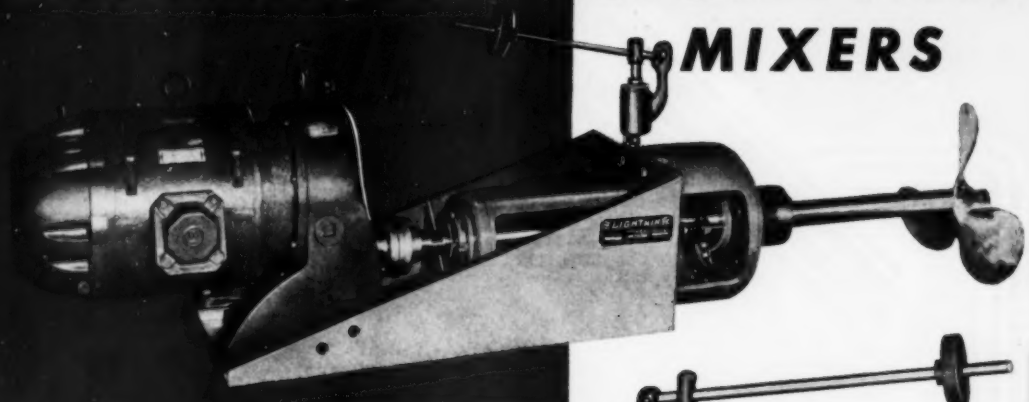
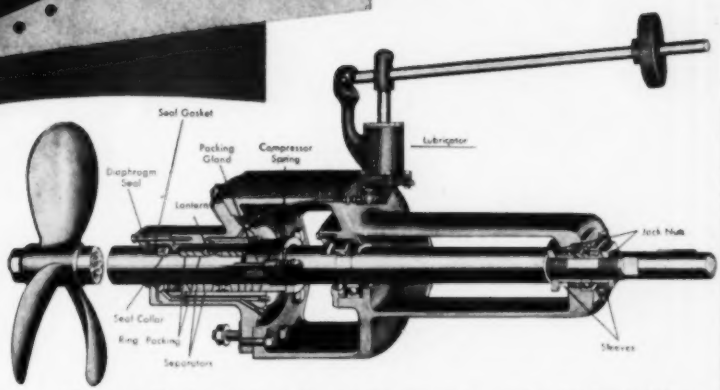
WHY REFINERIES STANDARDIZE ON . . . LIGHTNIN MIXERS





WITH LIGHTNIN MIXERS YOU ARE ASSURED OF:

1. Proper stuffing box performance. (See cross-section).
2. Shafts mounted in adequate bearing supports.
3. Shut-off device which enables repacking on Lightnin and Mixco Mixers with a full tank if necessary.

Designed for
Preferred for
Proved in
REFINERY SERVICE

Refinery Engineers have learned by experience that Lightnin Mixers will give maximum performance at the lowest possible maintenance cost because they are simply and soundly designed and constructed specifically for refinery service.

And remember, when you buy a Lightnin, you get a complete packaged unit, ready to install and operate. Nothing more to buy—nothing more to build. That's why Lightnins are lower in initial cost and installation costs.

PROCESS ADAPTED AGITATION
TOP-ENTERING
LIGHTNIN MIXCO
PORTABLES
SIDE-ENTERING

MIXING EQUIPMENT CO., Inc.

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IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

"LIGHTNIN" SIDE ENTERING MIXERS SPECIFIED FOR:
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"MIXCO" TOP ENTERING UNITS specified for the following, either batch or continuous operations: Treating • Suspensions • Heat Exchange Improvement • Gas-Liquid Contacting • Reaction Control

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Name _____
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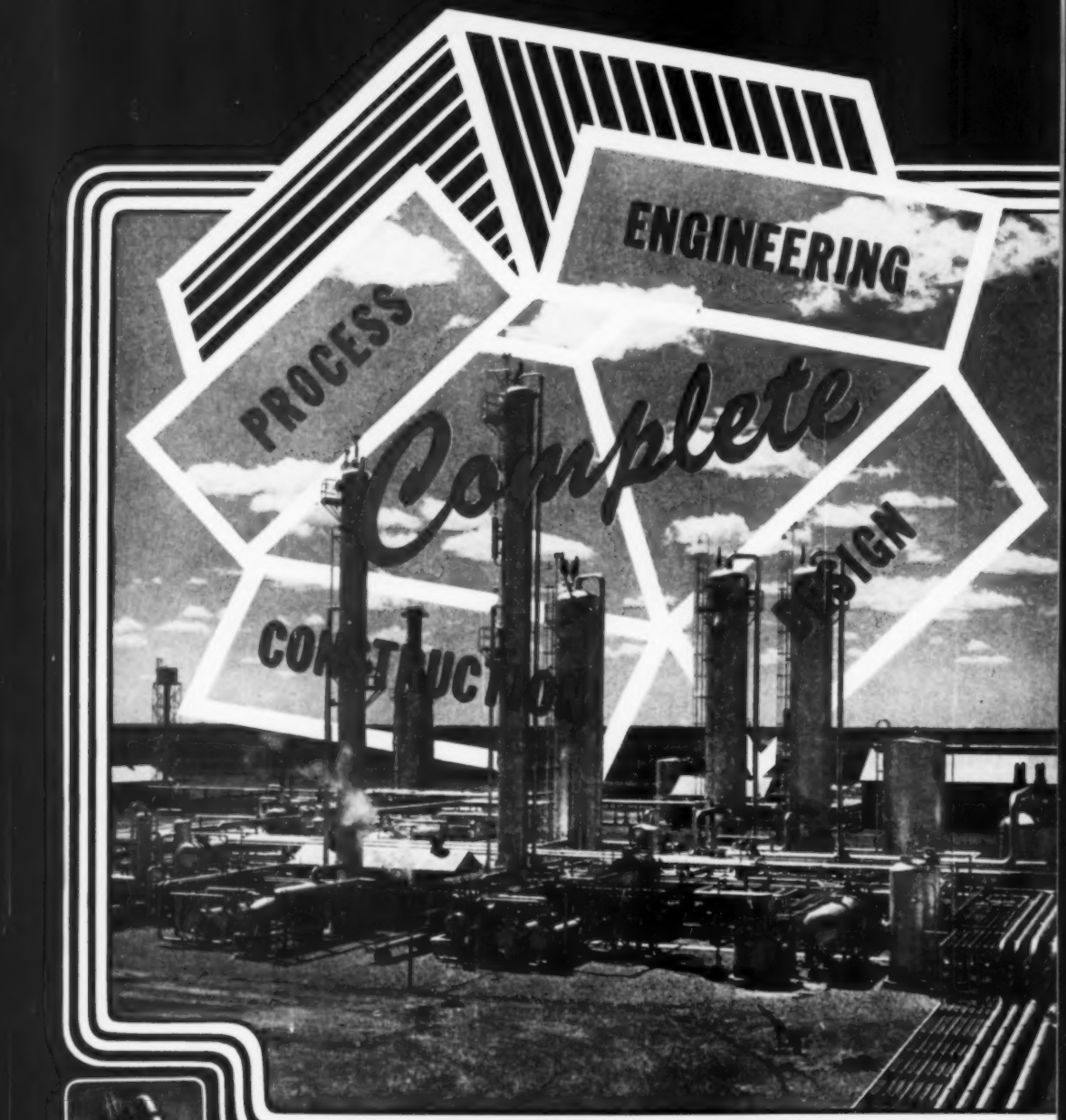
LIGHTNIN & MIXCO MIXERS ARE COMPLETE . . . READY TO OPERATE WHEN DELIVERED



Engineering and Construction Division

JONES & LAUGHLIN SUPPLY COMPANY

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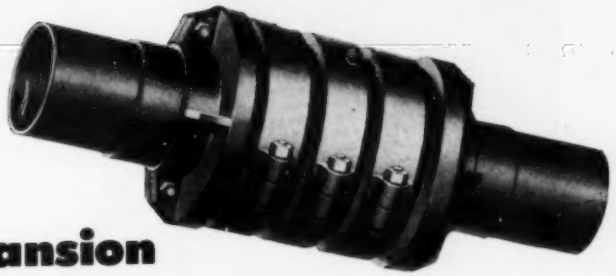


wherever
pipeline expansion
is a
PROBLEM

CMH Expansion Joints are the cost-saving, trouble-saving solution!

Common expansion joint problems of leakage, repacking, space limitation and complicated, costly installations are solved with CMH Expansion Joints. Compact, inline units, CMH Expansion Joints are easy to install—actually, they are standard piping sections. They require *no* maintenance . . . **and they don't leak.**

CMH Expansion Joints are available in either stainless steel or copper . . . Free-Flexing units for pressures up to 30 psi . . . Controlled-Flexing units for pressures up to 300 psi . . . **special units for unusually high pressures.**

Selection of the correct CMH Expansion Joint has been simplified to a matter of charts from which the joints necessary to meet your requirements may be chosen quickly and easily. CMH'S "Engineered Application Service" is also available to assist on unusual installations.

Full data on CMH Expansion Joints including the charts mentioned above are given in Bulletin EJ-49. Ask for a copy.

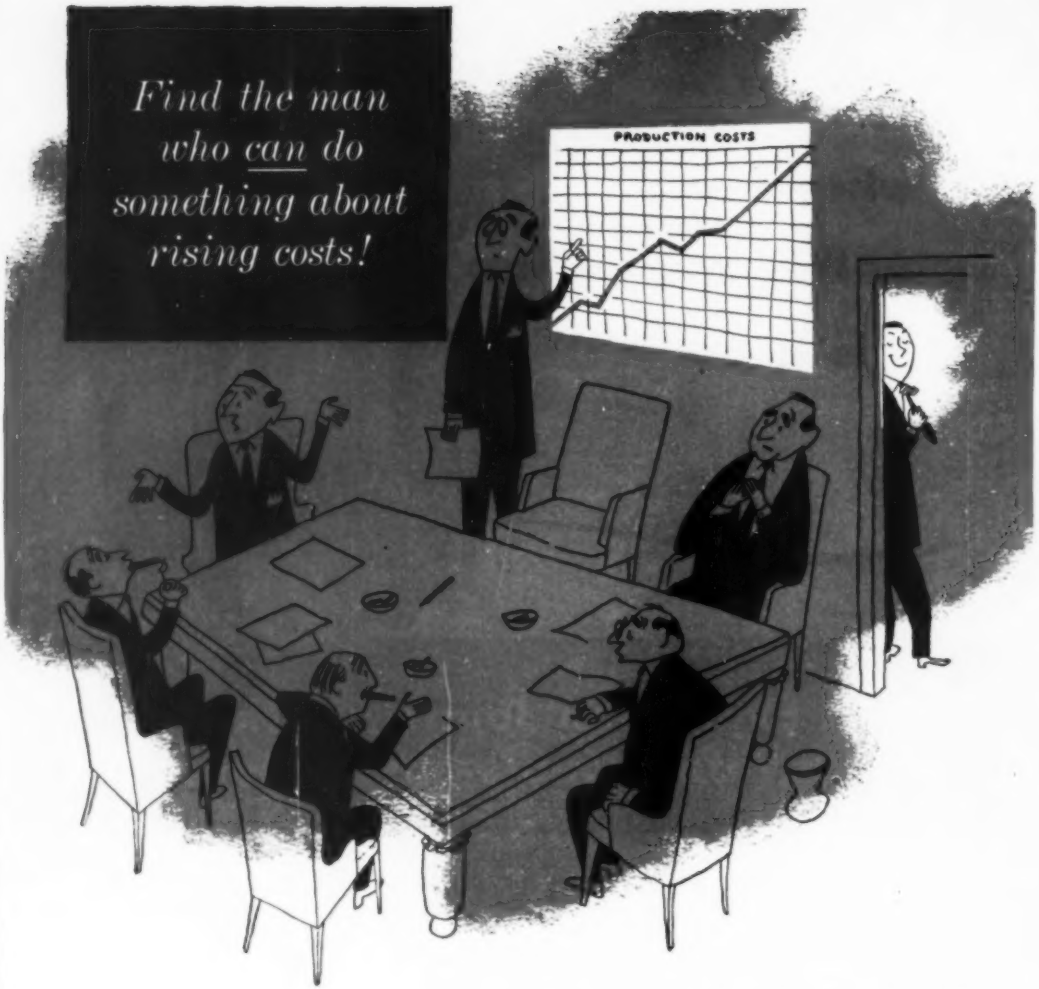
CMH—ONE dependable source
for every flexible metal hose requirement

• CMH manufactures all standard types of flexible metal hose, both convoluted and corrugated, in a variety of metals; expansion joints for piping systems; stainless steel and brass bellows; various conduits and special assemblies of these components.

FLEXON . . . . . identifies CMH products which have served industry for more than 47 years

CHICAGO METAL HOSE CORPORATION
EXPANSION JOINT DIVISION

Leaders in the Science of Flexonics
MAYWOOD, ILLINOIS
Plants at Maywood, Elgin and Rock Falls, Illinois
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ontario



In most businesses, operating costs are still on the rise. But there's *one* man who *can* do something about it—he's the man whose job is to get maximum heat and power from fuel dollars. He knows you *get* maximum efficiency from Eagle-Picher Industrial Insulations because they're made of durable, chemically and physically stable *mineral wool*, noted for its low conductivity. They give long years of service and are easy to maintain and replace.

There's an Eagle-Picher insulation that can help reduce *your* operating expenses!

Let these Eagle-Picher products also save you money . . . power . . . time

Insulating Felts
Supertemp Block • Blankets
Loose Wool • Pipe Covering
Stalastic • Insulseal • Insulstic
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THE EAGLE-PICHER COMPANY
General Offices: Cincinnati (1), Ohio

Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

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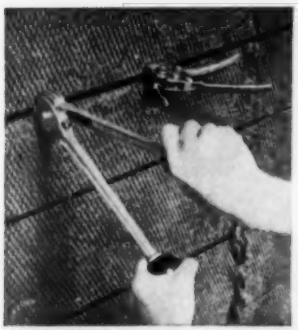
Since 1843

The perfect answer

FOR MAXIMUM FUEL SAVINGS AND EXACT TEMPERATURE CONTROL

For a completely effective, low-cost insulation combination, you can't beat the teamwork of Eagle-Picher Mineral Wool Blankets, Supertemp Blocks, Super "66" Cement and Insulseal. They work effectively to give your equipment higher efficiency . . . cut operating costs . . . and help to provide perfect, precise control over temperatures.



EAGLE-PICHER MINERAL WOOL BLANKETS

These blankets satisfy the need for a convenient method of quickly and efficiently insulating flat or curved surfaces on larger types of heated equipment. Mineral wool is felted and secured between flexible metal fabric. Outstanding physical and chemical stability enable Eagle-Picher Blankets to resist water, steam, corrosive fumes and normal vibration.

EAGLE-PICHER SUPERTEMP BLOCKS

Eagle-Picher Supertemp Blocks are lightweight (approximately 16 lbs. per cu. ft.). Can be cut easily with knife or saw to fit off-shaped areas . . . they fit snugly over minor irregularities. They're strong and have high refractory value. Withstand temperatures up to 1700 F. Conductivity at 512 F. approximately 0.43...all standard sizes, from 3" x 18" to 12" x 36" ...in thicknesses from 1" to 4".

EAGLE-PICHER SUPER "66" INSULATING CEMENT

Super "66" is all-purpose, rust-inhibitive, extremely adhesive insulating cement. "Springy ball" pellets don't collapse after application . . . give great coverage, retain their thermal efficiency. 100 lbs. covers 65 sq. ft. —1 inch thick! Easily applied with trowel, over flat and irregular surfaces. Efficient for temperatures up to 1800 F. Reclaimable when used on equipment whose temperatures go up to 1200 F.!

EAGLE-PICHER INSULSEAL

A tough, weatherproof, protective coating for insulation. For temperatures up to 450 F. Applied as a plastic, its smooth troweling qualities assure uniform coverage, proper thickness. It protects insulation from air infiltration, fumes, rain, snow, vibration, punctures, and withstands severe service, indoors or out. Dries to a smooth, rich black, has a neat appearance on hot or cold surfaces . . . may be washed or painted.

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Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

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Carried in Stock

Refinery engineers can count on two things when they order B7 studs from Bethlehem: (1) Getting the sizes they need, and (2) Good delivery. This is because Bethlehem stocks B7 studs in all diameters and lengths used by oil refineries. As for the steel from which these studs are made, B7 has what it takes for dependable service at medium-high temperatures and pressures. A chromium-molybdenum steel (AISI 4140, 4142 or 4145), B7 conforms to the requirements of ASTM Specification A193-48T. It fulfills the following chemical and tensile requirements:

B7 – CHEMICAL REQUIREMENTS

	Range	Check Variation, Over or Under
Carbon, pct	0.38 to 0.48*	0.02
Manganese, pct	0.75 to 1.00	0.04
Phosphorus, max, pct	0.04	0.005 over
Sulphur, max, pct	0.04	0.005 over
Silicon, pct	0.20 to 0.35	0.02
Chromium, pct	0.80 to 1.10	0.05
Molybdenum, pct	0.15 to 0.25	0.02

**For sizes over 3½ in., and up to 4 in., inclusive, the carbon content may be 0.50 pct, max.*

B7 – TENSILE REQUIREMENTS

	Minimum Tempering Temperature °F	Tensile Strength min., psi	Yield Point min., psi	Elongation in 2 in., min., pct	Reduction of area min., pct
Diameters 2½ in. and under	1000	135,000	115,000	15	50
	****1100**	**125,000**	**105,000**	**16**	**50**
	1200	105,000	90,000	17	55
Diameters over 2½ in., and up to 4 in., inclusive	1000	125,000	105,000	15	50
	1100	115,000	95,000	16	50
	1200	105,000	85,000	17	50
Diameters over 4 in., and up to 7 in., inclusive	1000	110,000	85,000	18	45
	1100	100,000	75,000	18	50
	1200	90,000	65,000	20	50

***Properties in bold-face type represent standard heat-treatment to be given material as stocked for use under the specification as agreed by manufacturers.*

B7 is one of seven grades of steel being produced by Bethlehem for high-temperature, high-pressure fastenings. The others are: B7a, B14, BA, BB, BC, and A261 —an all-inclusive range designed to meet virtually every need.

Bethlehem's plant at Lebanon, Pa., is well equipped for the manufacture of fastenings used by the oil industry. Our engineering staff is always at your service. Whenever you encounter a difficult bolting condition, get in touch with the nearest Bethlehem office, or drop us a line at Bethlehem, Pa. We'll be glad to hear from you at any time.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

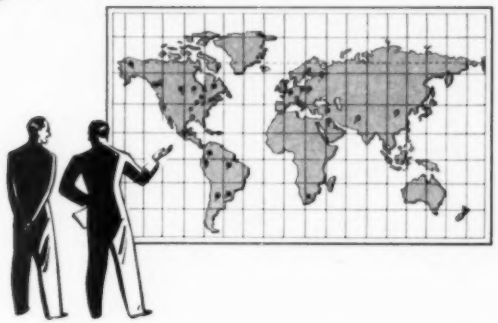
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

Bethlehem supplies every type of Fastening

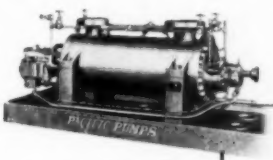
BETHLEHEM STEEL

FOR THE BEST IN
PRODUCTS AND SERVICE

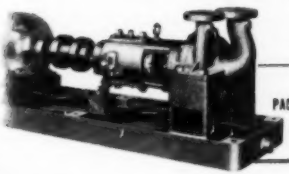
Engineers the World over specify PACIFIC *Precision Built* PUMPS



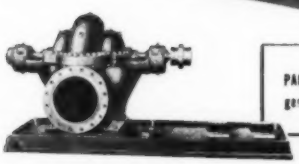
Engineered to the service requirements
Hydraulically designed for sustained efficiency
Mechanically designed for endurance and simplicity



PACIFIC TYPE **I**
hot charge pump



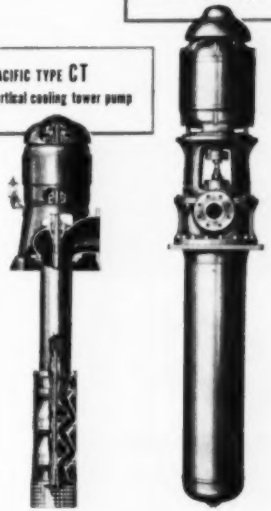
PACIFIC TYPE **SVC**
process pump



PACIFIC TYPE **DC**
general service pump

PACIFIC TYPE **WY**
vertical process pump

PACIFIC TYPE **CT**
vertical cooling tower pump



Pacific builds a complete line of Vertical and Horizontal Single and Multi-stage Pumps in all capacities, pressures and temperatures

25 YEARS

PACIFIC *Precision Built* **PUMPS**

PACIFIC PUMPS INC. HUNTINGTON PARK, CALIFORNIA
One of the Dresser Industries
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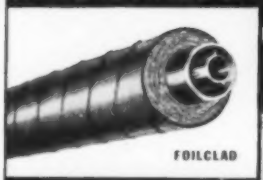
WHEN PIPING PLANS CALL FOR *Speed* – SPECIFY RIC-WIL

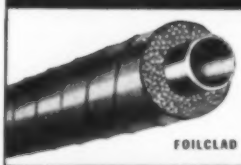
Custom-Built TO PROJECT SPECIFICATIONS



FOILCLAD

INSULATED, JACKETED PIPE

Pipe supported within a pipe, either to carry heating or cooling medium, other for process fluids.



FOILCLAD

REFRIGERANT LINES

Low temperature cork insulation, coated with asphalt and tension-wrapped with foil covering.

HEL-COR

UNILINE CONSTRUCTION

Helically corrugated iron housing, pipes nested inside insulation liner to maintain required temperature.

FACTORY PRE-FABRICATED INSULATED PIPING FOR STEAM AND VISCOUS FLUIDS

● Every construction engineer knows the loss of time, the hazards and the cost of sundry materials needed for insulating, waterproofing, wrapping and wiring of overhead pipe lines, when these operations have to be done on scaffolding. The Ric-wiL Unit method of installation eliminates most of this costly field work, makes possible phenomenal speed on the job and assures a permanent trouble-free system. Prefabricated 21-foot sections are delivered to job site, complete with pipe, insulation, couplings and accessories, and ready for hoisting onto trusses. Several units may be coupled on the ground before installation, minimizing overhead work under difficult conditions. On one job, 1500 feet of Ric-wiL Units were installed in place on channel steel uprights—with pipe welded and ready for couplers and insulation between units—*in only two working days.*

In Ric-wiL Foilclad Units, insulation is machine-coated with high temperature asphalt, then tension-wrapped with asbestos felt. This is followed by second coating of asphalt and finally covered with spiral tension-wrapping of foil, forming perfect bond with asphalt coating. In Ric-wiL Hel-coR Insulated Pipe Units, pipes and insulation are housed in 16 gauge helically corrugated galvanized iron housing.

Ric-wiL's full line of factory prefabricated accessories includes expansion devices, anchors, fittings, drip legs, valve connections and all other accessories required for fast, economical field installation.

Typical installation showing double overhead expansion loop for steam and return line.

For further information on Ric-wiL Insulated Piping write The Ric-wiL Co., Dept. 14V.

RIC-WIL

INSULATED PIPING SYSTEMS

THE RIC-WIL COMPANY • CLEVELAND, OHIO

REPRESENTATIVES IN PRINCIPAL CITIES

UNIBESTOS

pipe covering insulation at modern, natural-gasoline plant in Keystone field of West Texas

Photo: courtesy of Sid Richardson Company, Texas. Insulation Contractor, The Aber Company, Shreveport, La. and Houston, Texas.

UNIBESTOS No. 750 is suitable for temperatures up to 750° F. No. 1200 or Combination are recommended for temperatures up to 1200° F. These temperature ranges permit the use of one material at maximum efficiency for a wide variety of purposes. Unibestos is available in half-sections up to 30" pipe diameter, in quadrants up to 60" diameter, and in cylindrical form where specified. UNIBESTOS No. 750, No. 1200, and Combination are all furnished in single-layer constuction.

UNIBESTOS ASSURES SUBSTANTIAL SAVINGS IN TIME AND MONEY because of its high structural strength, long life and ease of removal and reapplication without loss of efficiency.

Top efficiency over a wide range of operating conditions . . . shock and vibration resistant pipe covering in single-layer construction that is extremely easy to cut, strip and apply . . . high physical and chemical stability . . . **THESE ARE JUST A FEW OF THE REASONS WHY SO MANY GIANT REFINERIES SPECIFY UNIBESTOS INSULATION.** Write today for complete data, the coupon below, is for your convenience.

UNARCO

UNION ASBESTOS & RUBBER CO.

Offices and Factory:
Cicero 50, Illinois

Offices:
Chicago, New York, San Francisco

Factories:
Paterson, New Jersey; McGregor, Texas; Bartville, Illinois; Marshville and Davidson, North Carolina

UNION ASBESTOS & RUBBER COMPANY
1823 South 54th Avenue, Cicero 50, Illinois

November, 1949

Gentlemen:
Please send sample ☐ and/or illustrated folder ☐ showing sizes, prices, conductivity curves and technical information to

Company.....

Address.....

Name..... Title.....

1. high fire resistance
2. low heat conductivity
3. excellent moisture resistance
4. immunity to many solvents

To meet industry's requirements for a refrigeration insulation that will stand up under many new kinds of service, Johns-Manville has developed Zerolite* . . . an entirely new *inorganic* low temperature insulation.

Zerolite is intended for industrial use where a dependable insulation with low heat conductivity is important to the economical operation of a system. The temperature range of Zerolite is from 400F below to 250F above.

Zerolite sheets, lagging, and pipe insulations are made from mineral wool, processed with a special resin binder that provides exceptional moisture resistance. Available in wide variety of sizes and thicknesses. The pipe insulation is further provided with an asphalt jacket that protects both longitudinal joints

**Reg. U. S. Pat. Off.*

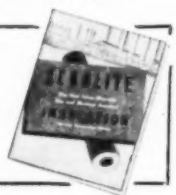
Skilled application service. To assure the maximum return from your Zerolite insulation investment, have your next job engineered and applied by a Johns-Manville insulation contract firm.

ZEROLITE is recommended for insulating:

Petroleum dewaxing equipment	Solvent storage and piping
Gas purifiers and condensers	Ammonia lines
Chillers and exchangers	Cold tanks and vessels
Chemical process lines	Cold water lines
Pharmaceutical process equipment	Freon lines
Reactors and economizers	Air conditioning equipment

Send for this Folder

This new folder contains descriptions, property tables and other data on Zerolite's advantages. Write Johns-Manville, Box 290, New York 16, N. Y.



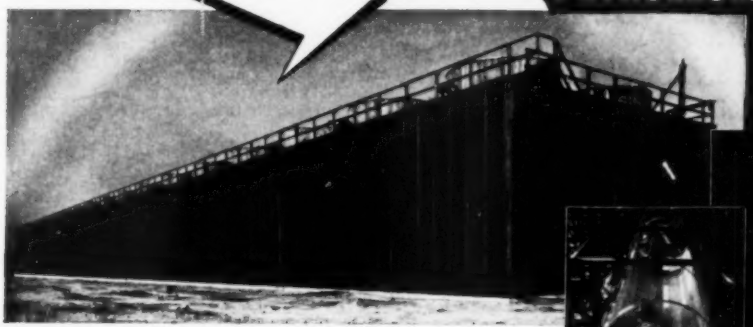
Johns-Manville **ZEROLITE**

REFRIGERATION INSULATION

WCEC

FOR THE WORLD'S LARGEST LUBE PLANT

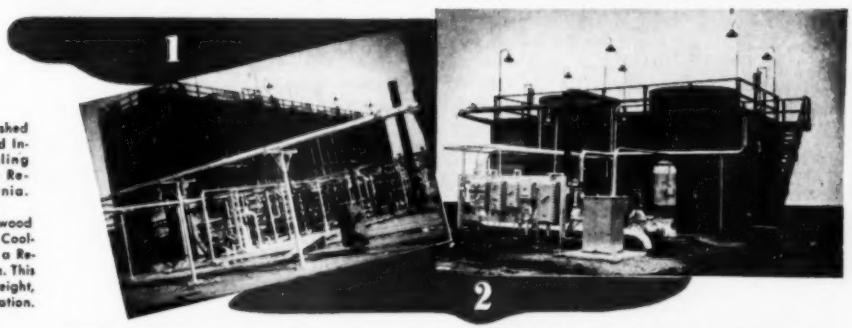
PETROLEUM INDUSTRY



The world's largest...51,000 gals. of water per minute... 3,060,000 gals. per hour...73,440,000 gals. of water per 24-hour day...cooled to a guaranteed temperature with this 34-cell Multi-Stage, Redwood Induced Draft Cooling Tower, engineered especially for Lube Plant in Louisiana.

Is 48-in. in diameter, banded at regular intervals.

SERVING THE SPECIALIZED NEEDS OF REFINERIES EVERYWHERE



1. Six-Cell, coil shed type, Redwood Induced Draft Cooling Tower serving a Refinery in California.

2. Two-Cell, Redwood Induced Draft Cooling Tower serving a Refinery in Oklahoma. This Tower is low in height, economical in operation.

ADVANCED ENGINEERING DESIGN MEANS SUPERIOR PERFORMANCE

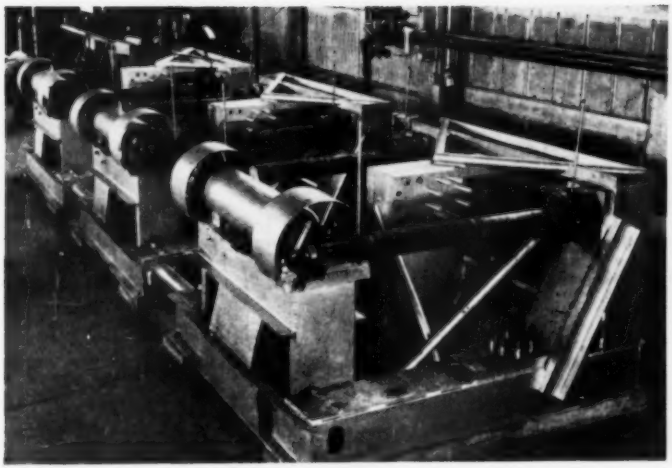
WCEC Cooling Towers today are being designed and built to handle any specified service demanded by any specific industry. In the Petroleum field, for instance, WCEC has designed and engineered a Cooling Tower meeting the specialized needs of the World's Largest Lube Plant. What we have done for them, we can do for you.

WATER COOLING EQUIPMENT COMPANY

FABRICATING PLANTS • • • ARCATA, CALIFORNIA • • • HOUSTON, TEXAS • • • ST. LOUIS, MISSOURI

ADDRESS INQUIRIES HOME OFFICE: ST. LOUIS 23, MO.

The insulation is up to stay...
Insulation failure spells only one thing...extra expense.
Patching and reinsulating means paying for labor, materials, and expensive scaffolding. In most cases, this extra maintenance expense is needless.
Here's why:
When you band with rustproof, corrosion-resistant MONEL*, your pipe and tower insulation is up to stay...usually for years on end.
MONEL banding, band clips, netting, and reinforcing wire resist common industrial and marine atmospheres; and are as strong as structural steel. Yet, despite unusual toughness and hardness, MONEL is ductile. It does not work harden or embrittle; can be stressed like steel ...features that make MONEL insulation-retaining bands and wire easy to apply.
On your next insulating job, insure future savings ... use MONEL.
A note to INCO will bring you full information and a list of distributors. *Reg. U. S. Pat. Off.
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.
MONEL* . . . for minimum maintenance



Strength through Design in Tube-Turn welding flanges

Taking the measure of piping fatigue

PIPE lines are *live, dynamic* members of a piping system. They *breathe* with changes in temperature and pressure. And the danger of fatigue failure from pressure shock, thermal shock, and cyclic conditions is ever-present.

More precise information was needed on this subject. So, Tube Turns research engineers set out to get the answers. For the purpose, they designed and built a unique cyclic testing machine to handle full-size piping assemblies under a wide range of temperature, pressure, and corrosive conditions. And on this torture rack they subjected flanged assemblies to reverse bending tests carried on to ultimate failure. Information revealed forms the basis of new designs for greater strength in Tube-Turn welding flanges.

Other piping assemblies, too—welding elbows, mitre bends, manufactured and fabricated tees, pipe bends—have been subjected to punishment more severe than any they would probably face in normal service.

And this perpetual search for greater strength through better design has paid off in the form of realistic, non-theoretical facts providing a sound basis for Tube Turns' manufacturing policies—facts important to anyone interested in getting his money's worth in long life from piping installations.

Tube Turns' research and development organization, finest in the welding fittings industry, is constantly striving for the improvement of present products, the development of new ones. Notable among their recent achievements have been the design of a new type welding tee and the development of aluminum welding flanges.

Ask to be put on the mailing list for Tube Turns' technical periodical, *Piping Engineering*. Paper 6.01, for instance, deals extensively with standard steel flanges. Others give you research findings and additional working information pertaining to piping not generally available in convenient form.

TUBE-TURN

tt

WELDING FITTINGS AND FLANGES

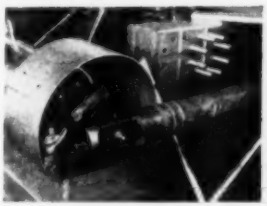
TUBE TURNS, INC.

244 East Broadway, Dept. K, Louisville 1, Kentucky

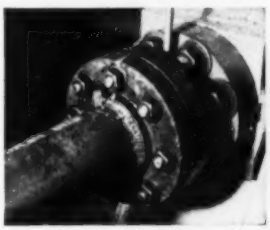
District Offices at New York, Philadelphia, Pittsburgh, Chicago, Houston, Tulsa, San Francisco, Los Angeles

TYPICAL FLANGE ASSEMBLY TESTS

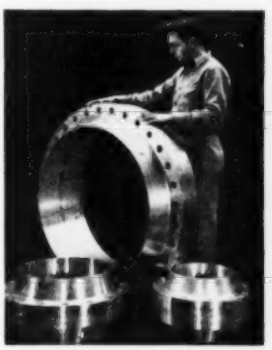
Assemblies were of 4-inch nominal size with 300 pound forged steel flanges and standard weight pipe.



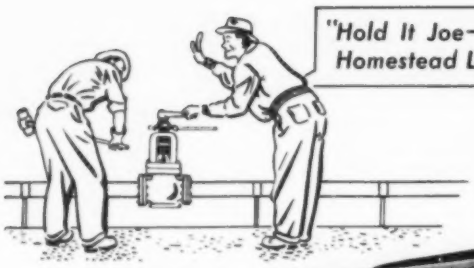
Eccentric crank arm produces up-and-down movement which creates a cyclic bending moment on flange or fitting at opposite end of assembly.



Water spurts from crack in test specimen. Almost invariably, failure occurred in the pipe adjacent to the flange.



Aluminum welding flanges . . . another Tube Turns first! Available in a wide range of types and sizes.



Homestead
LEVER-SEALD
Valves

ALWAYS WORK
LAST LONGER
COST LESS PER YEAR

STICKING valves are never a problem with Homestead Lever-Sealds on the job. Built into each valve is a powerful leverage, ready at all times to overcome the effects of corrosion, viscous fluids or temperature and pressure extremes which cause ordinary valves to stick or "freeze."

This powerful leverage not only relieves pressure between the seating surfaces to permit operation under all conditions; but it also is the means of providing the extra tight seal against leakage—the seal which keeps corrosive or erosive line fluids away from the seating surfaces; assures longer valve life and lowest cost per year.

Made in stainless steel, steel, semi-steel, bronze, monel or other alloys suitable for the working conditions under which they are to be used, Homestead Lever-Seald Valves may be had in sizes from 1" to 12"; and for working pressures from 150 pounds to 1500 pounds.

Choose the sizes and types for your services from Reference Book 39 Section 3. Write for your free copy today.

Check these Outstanding Features:

A QUARTER-TURN fully opens or closes valve.

INSTANT STICK-PROOF OPERATION. Plug turns freely after seating pressure is relieved by screw lever.

POSITIVE LEAKLESS SEAL is obtained by applying full seating pressure with screw lever after opening or closing.

LEAK PROOF. Deep stuffing box, gland and sealed bottom prevent fluid loss, and reduce hazards.

STRAIGHT-LINE FLUID FLOW. Little or no pressure drop.

SEATING SURFACES ALWAYS PROTECTED in both open and closed positions. Fluid or grit cannot damage valve seat.

HOMESTEAD VALVE MANUFACTURING CO.

P. O. BOX 16 CORAOPOLIS, PENNA.

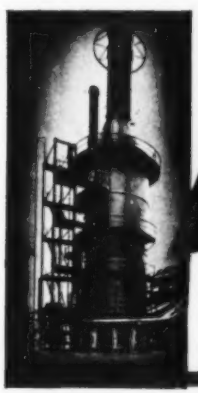
LOW FIRST COST IS ONLY ONE FACTOR FOR COMPARISON IN THE PURCHASE OF A FURNACE

CHECK ALL THE FACTORS

. . . you'll find
PETRO-CHEM ISO-FLOW FURNACES compare more than favorably in every respect . . .

- LOW INITIAL COST
- EVEN HEAT DISTRIBUTION
- HIGH EFFICIENCY
- UNIFORM RADIANT RATE
- LOW MAINTENANCE
- FLEXIBILITITY OF DESIGN
- STANDARDIZATION
- PORTABILITY
- ACCESSIBILITY OF PARTS
- PLUS EXPERIENCE AND NUMBER IN OPERATION

There's a Petro-Chem Iso-Flow Furnace and Boiler for any service, capacity or duty, irrespective of temperature pressure ranges. More than 600 are in satisfactory operation throughout the world.



FOR YOUR FURNACE REQUIREMENTS

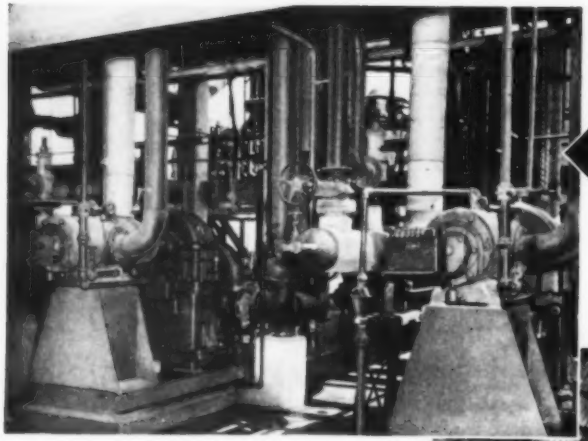
PETRO-CHEM ISO-FLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INCORPORATED

120 East 41st Street • New York 17, N. Y.

Representatives: Bethlehem Supply, Tulsa and Houston • Flagg, Brackett & Durgin, Boston • D. D. Foster, Pittsburgh • Faville-Levally, Chicago • Lester Oberholz, California

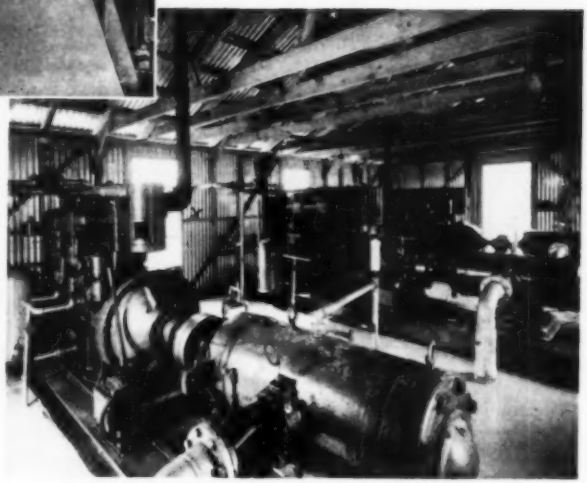


IN THE REFINERY

Two of six Fuller Rotary Single-stage Compressors in a refinery. Capacity each, 475 c.f.m., 45-lb. pressure. Turbine drive.

IN THE FIELD

FULLER ROTARY COMPRESSORS ARE EFFICIENT AND DEPENDABLE



Three Fuller Rotary Single-stage Compressors, applied to boosting of natural gas. Capacity each 1,450,000 cu. ft./24 hrs., from 5-lb. gage to 25-lb. Natural gas-engine drive.

Fuller Rotary Compressors, in the refinery for general plant air, purging gas, refrigeration in alkalization units, and handling butane-butylene, as well as in the field for pressure boosting and gas gathering, have proved their worth, as is evidenced by the hundreds of these machines in use throughout the industry.

The ability of Fuller Rotary Compressors to perform, day in and day out, with minimum attention and maintenance, has earned for them a well deserved position in the oil fields. Particularly adapted to handling of weak wells, and the volumes demanded, without creating a serious maintenance problem, they have proved to be an economic and practical answer to diminishing pressures. Their flexibility and low cost make them adaptable to varied conditions.

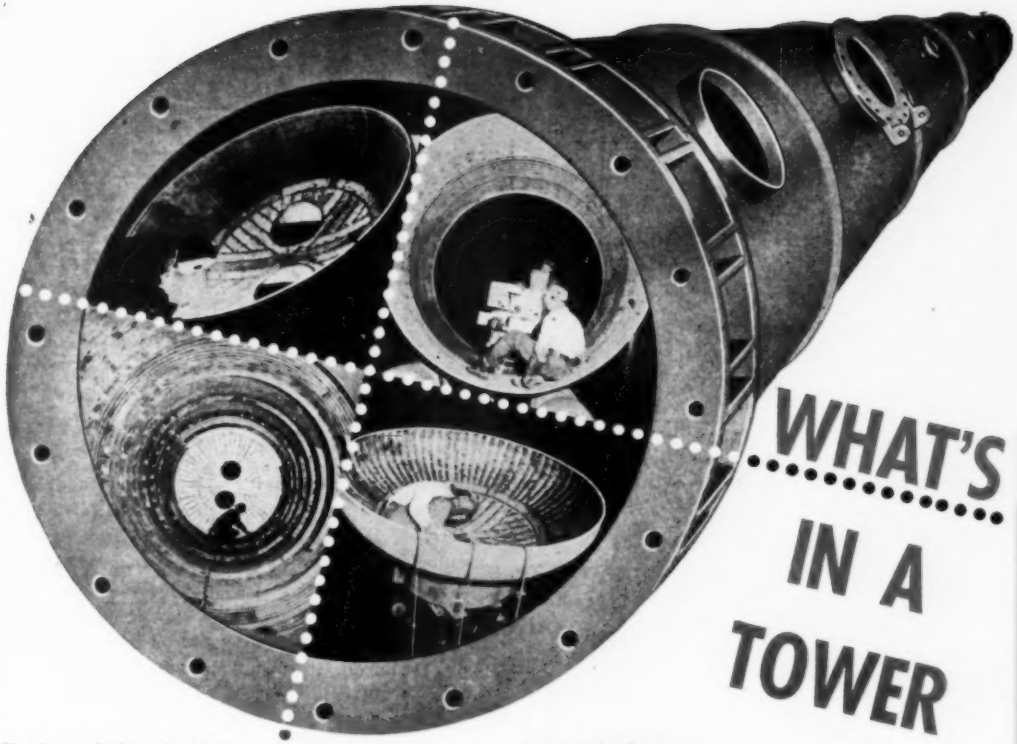
It will pay you to become acquainted with Fuller Rotary Compressors and Vacuum Pumps. We'll be glad to send you Bulletin C-5, describing these machines.

FULLER COMPANY
CATASAUQUA—PENNSYLVANIA

Chicago 3 - 120 So. LaSalle St.
San Francisco 4 - 420 Chancery Bldg.

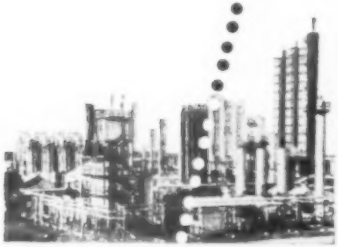
FULLER A LIFETIME OF NEW MACHINE EFFICIENCY

C-186



WHAT'S IN A TOWER

Fluid catalytic unit tower 8'0" ID x 50'0" 3/8" steel shell, clad with 12 gauge stainless steel strips, complete with tray supports...Nooter fabricated to Universal Oil Products Co. design.



besides design and metal?

Well, for one thing: Over one mile of Nooter *DuraPure* Welding. The continuous automatic and manual arc-welded construction surpasses API-ASME Code specifications. . . Uniform bond achieves high strength, and surface purity of welds maintains corrosion-resistance. Stress-relieving insures safety and precise, undistorted alignment.

After being cross-checked for precision fit-up the vessel was shipped on schedule — ready for erection.

This is why Nooter-fabricated equipment is competently serving the petroleum industry throughout the world.

When your blue prints are ready — call in Nooter!

NOOTER

Nooter Catalog, complete with corrosion data charts is sent at your request.

NOOTER CORPORATION • 1404 S. Second St. • St. Louis 4, Mo.

Coked up? *give it a dose of Lagonda "zip"!*

One good treatment by the Lagonda 1100 Series cleaner, with the correct type of cutter head, will make that logy still jump up into the harness just like old Dobbin used to when you reached for the whip socket in the old horse and buggy days.

Before your time? Well maybe, but Lagonda cleaners were good medicine for fouled tubes before old Dobbin got auto-conscious. They're even better now. Start one through a coke-laden tube and hear it sing its way all down the tube without a wavering note. That cleaner has reserves of power that it just turns on when the going gets tough. No slowing up and laying down in the hard going. This is the Lagonda quality that is getting stills back on stream everywhere in record time, and keeping refinery engineers happy.

Write for the Lagonda 1100, Series Bulletin, and get full data on these cleaners and their cutter heads. And if you have a tube cleaning job that is holding things up, ask us to arrange a Lagonda demonstration. No obligation.

Y-289

Elliott COMPANY

Lagonda Division, SPRINGFIELD, OHIO

Plants at: JEANNETTE, PA. • RIDGWAY, PA. AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.

DISTRICT OFFICES IN PRINCIPAL CITIES

PLUGS ARE OUT WITH CHLORINATION

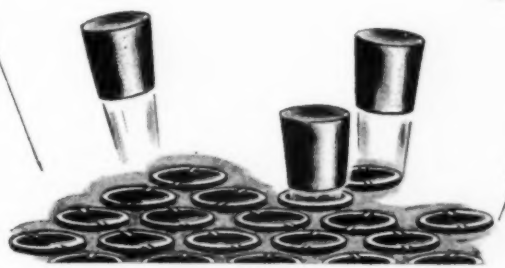
Costly plug cleaning, with its high labor bills and lengthy equipment down-time, goes out of the condenser and heat exchange picture the minute chlorination arrives.

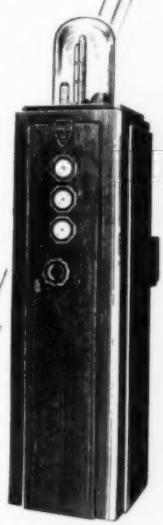
This proven process for cutting the costly effects of back pressure and poor heat transfer characteristics caused by slime, really works, as one Southern Power Station found out when they began using the W&T De-sliming Process. In just six months after W&T Chlorinators were installed, cleaning and excess steam costs were reduced from $1450 per month to $250 per month and a later survey showed an overall saving in excess steam costs of $16000 in a year.

Such savings are indicative of how your condensers may be made to operate more economically and with far less outage when W&T Engineers install chlorination to fight your slime problems.

To learn how chlorination may be profitably applied to your heat exchange equipment and to take advantage of W&T's 35 years' experience, write today.

WALLACE & TIERNAN
PRODUCTS, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
Belleville 9, New Jersey • Represented in Principal Cities

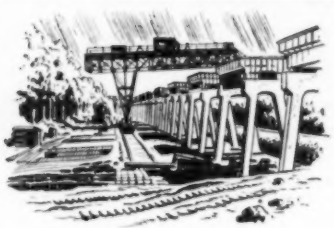




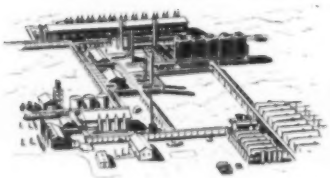
CD-31

Rx PRESCRIPTIONS FILLED QUICKLY AND ACCURATELY

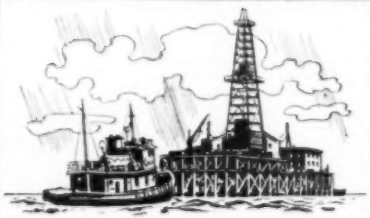
● A complete, permanent city set up by Brown & Root on Guam Island. Constructed to meet rigid governmental requirements, this community poses every problem of construction and development. When completed, it will stand as an achievement of overall planning and competent contracting covering every phase of the operation.



● Spanning more than three miles of Louisiana lowlands, construction of this "Brown-Bilt" trestle required specialized equipment designed to combat the unstability of swampy soil prevalent in Louisiana floodways. Reinforced concrete, set on 675,500 lineal feet of piling, assured an engineered travelway of staunch stability . . . a complete Brown & Root project fulfilling the maximum requirements of client specification.



● Shell Oil Company's TXL Gasoline Plant near Odessa, Texas. This is a prime example of Brown & Root's flexibility in meeting the demands of a client's changing conditions. The original contract called for a 30,000 mcf gasoline plant. During plant construction the mcf was revised to 45,000. Shortly after completion, the throughput demands were raised to 90,000 mcf . . . triple the original requirements! Farsighted planning by Brown & Root engineers allowed continuous plant operation while this tremendous project was effected.



● Offshore drilling. Derrick foundation constructed by Brown & Root Marine Operators, Inc., for a drilling operation far out in the Gulf of Mexico. "Brown-Bilt" in six fathoms of open water, its crown block towers 237 feet above the floor of the turbulent Gulf. It must withstand not only storms of hurricane strength but also the rigors of heavyweight rotary drilling operation.

BROWN-BILT

BROWN & ROOT, Inc. *Engineers & Constructors*

P. O. BOX 3, HOUSTON 1, TEXAS

CABLE ADDRESS — BROWNBILT

Associate Companies:— BROWN ENGINEERING CORP. ● BROWN & ROOT MARINE OPERATORS INC.

THE British under their present form of socialistic government are headed for a low rung on the ladder of the nations—and their future as a world power is hopeless if the present system continues.

Socialism or Free Enterprise

This is the opinion expressed by Thurman Sensing, the director of research, Southern States Industrial Council, in a recent talk before the Western Petroleum Refiners Association, at Shreveport, La. Sensing was recently sent to England by the Council. His purpose was to obtain information on the functioning of a socialist government, and on its effects upon the freedoms and economy of a people. The Council headquartered in Nashville, Tenn., and devoted to the economic and industrial development of the South, had concluded that a major decision ahead of the people in this country at the present is the choice between free enterprise and socialism.

Sensing said that he spent eight weeks, 15 to 18 hours a day getting information for his report. He talked to all sorts of people in all walks of life. He talked with a group of socialist members of Parliament. He talked with conservative members of the House of Commons, with members of the House of Lords, Lord Mayors of London, Birmingham, and Edinburgh. He traveled over England, Scotland, and Wales, and talked with the representatives of socialist magazines and publications. He contacted such organizations as the Federation of British Industries, National Union of Manufacturers, Association of British Chambers of Commerce, and the British Transport Commission. He talked with the chairman of the Cotton Board at Liverpool, the Minister of War, the Minister of Transport, officers of the National Farmers Union, and the British Medical Association.

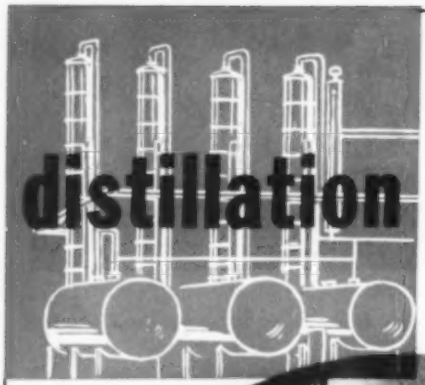
After four and one-half years of peace, Sensing said, they are the only major nation in the world with strict rationing and price control. Their rate of taxation is almost unbearable—40 percent of their national income goes into their income tax. Last year they levied a special 10 percent tax on all invested wealth in Great Britain. Their death tax ranges from 50 to 80 percent for sizeable estates.

The past four and one-half years has been a world-wide seller's market, which favors industrial nations, such as Great Britain. Instead of developing export trade, promoting their internal development and economy, increasing their efficiency and man-hour production, however, Britain has largely devoted all their time, funds, and energies to experimenting in socialistic projects, he said. Now, they have just about priced themselves out of the market, forcing their recent devaluation of their currency. That move, Sensing said, is not a cure at all, but another opiate to add to the several they've had during these four or five years. Food subsidies last year cost the British $1.94 billion or one-seventh of their total national budget.

When the Socialist government nationalized the coal mines, they lost $92 million the first year they operated them. Nationalization of the railroads resulted in a loss of $120 million the first year. They nationalized civil aviation and lost $100 million the first year. They have nationalized utilities, gas, electricity, cables and wireless and are now nationalizing the steel industry.

Socialized medicine was estimated for the first year at a cost of $608 million, but actually cost $1040 million. The cost for the second year is estimated at $1200 million. Doctors are paid $3.40 per patient per year and it makes no difference whether the doctor waits on the patient once or a hundred times. It works out that the doctor receives $6800 per year, from which must come all nursing assistance, office rent, and other overhead. Hospitals and doctor's offices are overcrowded.

It is tragic, Sensing said, to see the frustration and the near hopelessness of the British people. More important to us is whether or not we are learning our lesson from their experience. If this country more fully accepts "the government-will-take-care-of-you" philosophy, we will betray the whole heritage that has been founded for us. More than ever in our history, we need to realize the price of liberty is eternal vigilance. Now is the



distillation processes and equipment for . . .

. . . the separation of hydrocarbons or other organic chemicals, should be designed for efficiency in terms of overall operating costs and amortization of capital investment. Tray efficiency, cleaning facility and resistance to corrosion are the principal factors to be considered. For practical purposes, tray efficiency or tray spacing may be reduced to keep tower cost at a minimum. A balance of utility costs against chemical recovery may indicate the desirability of sacrificing some of the recoverable material, with a corresponding reduction in the capital outlay for columns and associated calandrias, condensers and heat exchangers. Particularly when potential changes in process or product specifications are foreseen, distillation columns with sectional shells and removable trays of light alloy construction offer special opportunities for economy because of the ease of transfer from tower to tower as well as cleanability and resistance to corrosion.

New technical bulletin, DISTILLATION ENGINEERING AND EQUIPMENT, is available on request.

Distillation columns of copper construction 60 feet in height with diameters from 72 to 78 inches.

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time to stop socialism in the United States.

"The responsibility for stopping socialism rests on people just like you and me," Sensing said. He pointed out that while most individuals agreed with most of the things he said in his speeches over the country, they did not believe their group needed the message, but rather that it should be gotten across to those who are not aware of the dangers and evils of socialism. While these individuals agree that this country is headed down the road of socialism, they are not themselves doing anything to spread general knowledge of the factors involved in the alternate systems.

A passive belief in freedom will not solve the problem, he said. Citizenship in a free democratic form of government imposes an individual responsibility.

Sensing recounted that one individual, an important business executive, who claimed he did not need to be told of socialism, said he "did not understand why everyone cannot see that we are headed for socialism," and that he, "wonders when the people will wake up?" Sensing said he happened to know that this individual seldom votes at election, and that he takes no firm position before his employes or before the public on issues that vitally affect the preservation of the free enterprise system. Since the system makes the existence of his business possible, the question, Sensing said, is more aptly stated, "When will he wake up?"

If the United States goes all the way along the road to socialism, Sensing said, the responsibility for doing so will rest squarely upon the shoulders of our civic and professional and business leaders —upon our so-called better class of citizens—upon those who say: "Get the message to those who need it; I don't need it." There is a responsibility of leadership which cannot be ignored. He concludes, "I am personally convinced that if all the business and industrial and professional leaders of this country would carry out their full responsibility as individual citizens, if they would work together and give their whole-hearted support and time and means to the preservation of our traditional American way of life, the America we have known would be kept for our children. Otherwise, it will not."

Today a little more than one person out of every seven in the population is a regular recipient of government monies. If those of age are all married, they comprise about one-half the voters of the last presidential election.

HERBERT HOOVER
75th Birthday Address

Oil Men Are Busy Men

THE Natural Gasoline Association of America recently held another regional meeting. As a result of the selection of subjects, speakers, and the general program arrangement, for this Tyler, Texas, meeting, the association can check off another highly successful occasion. Attendance was nearly 400 and the degree of interest, we observed, was exceptionally high. The meeting was held in cooperation with the East Texas Natural Gasoline Men's Club.

Back in the early days of the NGAA, regional meetings were the "Plant Operator's" meetings. The name was entirely appropriate. However, as the industry grew and the fundamentals of plant operation became more common-place and practices and procedures more or less conventional, these meetings were discontinued. The annual conventions of the association were then used to summarize new developments for the entire industry.

During 1940 the Association began to make plans to again hold regional meetings, realizing that they should never have been stopped. They were not able to proceed because of the war. The war period proved a period of transition in process development for the natural gasoline industry. These changes warranted resumption of the regional meetings. It was realized also that the yearly conventions were crowded with broad discussions of industry policy and economics, so that too little time could be given to consideration of the technical phases of plant design and operation. Also, the geographic spread is such that many operators cannot attend the annual conventions.

The regional meetings, first resumed in December, 1947, provide operating men with more opportunities to discuss and solve their many plant problems. Programs are arranged by committees from the region involved. These committees select the speakers and their subjects. Their discussions are practical in nature.

Sponsorship of the meetings is the principal function filled by the NGAA. The NGAA arranges, too, that all presentations of the meetings are printed and bound and that copies are distributed. Thus the operators are provided with authoritative information on the phases of the industry in which they are interested. The NGAA, a service organization by the industry and for the industry, furthers its principal reason for existence. Our congratulations on this well chosen program which is greatly increasing the effectiveness and utility of the organization.

Basically standardized

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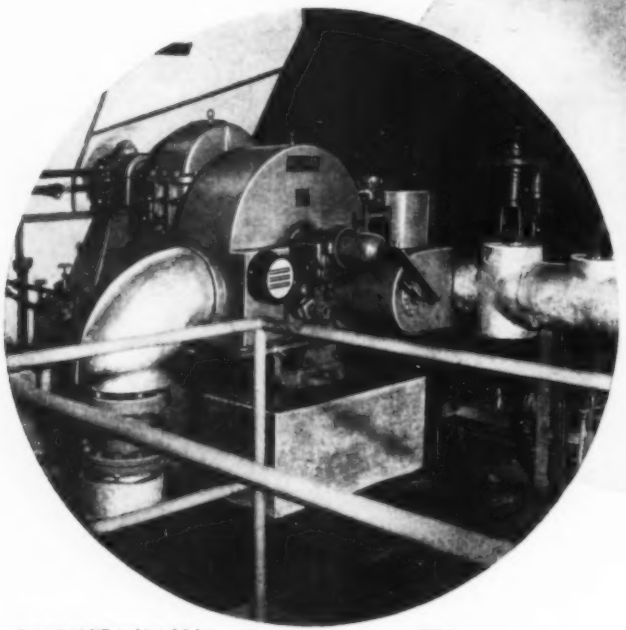

A standard YR turbine driving induced draft fan through built-in gears. A compact, workmanlike installation.

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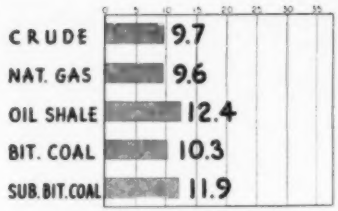

Figure 1. Direct Cost of Liquid Fuels (cents per gallon)

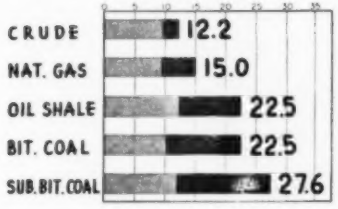

Figure 2. Direct Costs plus Investment Costs of Liquid Fuels (cents per gallon)

COAL and oil shale will eventually supplant crude petroleum as the major raw material for gasoline, diesel fuels and burning oils, but agreement about the future of synthetic fuels ends at that point.

Controversies exist on two important problems—1) When will a synthetic fuel industry be justified, either by economics or by necessity, and 2) What course should the nation and the industry follow in preparing for the advent of synthetic fuels?

In a normal economy with a plentiful supply of petroleum like we have today, liquid fuels from coal and oil shale will appear only when they can compete with products from petroleum. On the other hand, when a plentiful supply of oil no longer exists, sufficient economic adjustments will occur to make a synthetic industry possible.

Synthetic fuels from coal and oil shale cannot compete in today's market. Inasmuch as they are not now economical, recent proposals have recommended that the government subsidize a synthetic fuel program. The proponents of such a policy state that such a program is justified as a security measure.

After thorough study, we believe that the nation should *not* enter into a synthetic fuel construction program now. The nation is in no danger of a liquid fuel shortage in the near future. As a matter of fact, supplies of oil will probably be great enough to make such a program unnecessary for at least another 10 years. Even in the case of war, supplies of liquid fuels should be adequate without turning to coal or oil shale before 1961.

Stanolind Oil and Gas Company recently completed an analysis of the current competitive position of liquid fuels from coal and oil shale as compared with those from oil and gas. The background for this analysis has included several years' extensive research work on synthetic fuels at Stanolind's laboratories where considerable experience was gained in connection with designing the Hugoton gas synthesis plant, a project which was later suspended.

The results of Stanolind's analysis have been published in a paper, "Liquid Fuels From Coal and Oil Shale," which appeared in the September issue of the *Journal of Petroleum Technology*.

Stanolind's studies together with a thorough survey of all available information show that the production of liquid fuels from natural gas, coal and oil shale is technically feasible. The technology of synthesis from natural gas is already highly developed. As a mater of fact, a commercial synthesis plant of this type is now nearing completion at Brownsville, Texas. However, technical progress on synthesis of coal and oil shale has not advanced as far. These processes still remain in an immature state of development.

Studies of cost, also reported in that article, show that liquid fuels from coal and shale cannot compete successfully with products from petroleum in today's market. Figure 1 shows the direct costs of products from coal and oil shale, as compared with those from oil and gas. These costs were based on processes considered to be technically feasible today. They include costs of mining, manufacture and transportation. The *direct* costs of making a gallon of gasoline from these raw materials are not far different. Gasoline from crude is 9.7 cents per gallon, and from natural gas, it is 9.6 cents. On the other hand, gasoline from oil shale is 12.4 cents per gallon; that from bituminous coal is 10.3 cents; while that from sub-bituminous costs 11.9 cents.

To provide a true basis for comparison, it is necessary to include charges for depreciation and profit. A reasonable return on investment would be 14 percent a year. This return would take care of depreciation and allow an income after taxes sufficient to pay off the investment in 10 years. In plants of this type, with such a high obsolescence factor at this stage of development, a 10-year payout period would certainly not be unreasonable. When these investment charges are added to direct costs, the total costs of liquid fuels vary as shown in Figure 2. On this basis, gasoline from crude would cost 12.2 cents per gallon, and that from natural gas would be 15.0 cents.

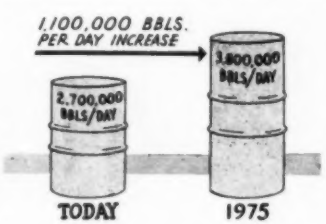

Figure 3. Gasoline Demands

WHEN DO WE NEED

A Synthetic Fuel Industry?

A. L. SOLLIDAY
Executive Vice President, Stanolind Oil and Gas Company, Tulsa

***THE QUESTION** of whether synthetic fuels are needed now or later is a vital one to the American public. This discussion by A. L. Solliday, presented at the San Antonio meeting (October 6, 1949) of the Petroleum Branch of the American Institute of Mining and Metallurgical Engineers, bears directly on this problem. Mr. Solliday's presentation contains the major conclusion resulting from extensive studies by Stanolind on processes for synthetic fuels and analyses of the economics involved.*

But costs for oil shale and bituminous coal would rise to 22.5 cents a gallon, while that from sub-bituminous coal would be 27.6 cents.

These figures include transportation costs to a common marketing area. If a plant using natural gas were more favorably located to its market, much of the difference in cost between crude and natural gas would be eliminated. However, even lower transportation charges cannot greatly affect the cost position of gasoline made from coal or oil shale.

Cost to Consumer

While this figure does not show it, the final cost to the consumer would be still higher. The motoring public now pays an average of about 15 cents per gallon above manufacturing costs. This 15 cents covers such additional costs as state and federal taxes, profit for dealers, tank wagon distribution and so on. Thus, retail prices for gasoline from coal and oil shale would be as much as 40 or 45 cents a gallon.

Recent Bureau of Mines statements with regard to synthetic fuels have included many cost items, ranging from the cost of shale mining to the cost of a 10-million-barrel-per-day synthetic industry. Most of this information, as reported in the press, does not indicate what cost items have been included and what ones have been left out. Nor do these reports indicate the basis for figures quoted.

For example, the Bureau recently stated that crude shale oil could be produced at a cost of $2.25 to $2.50 a barrel. The public would assume from this that crude shale oil would be competitive with petroleum. Such is not the

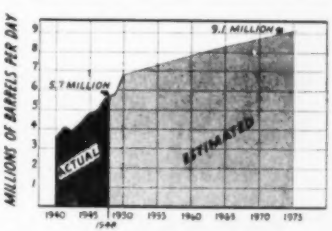

Figure 4. Total Daily U.S. Demand for Petroleum

OHIO FUEL GAS CO. Hundreds of OIC Valves are installed at the Ohio Fuel Gas Company's 70-tank Mt. Sterling Compressor Station, about 20 miles southwest of Columbus, Ohio.

FOR PROPANE GAS SERVICE . . .

PUBLIC utilities which supply propane gas to supplement natural gas at times of peak demand, as well as the companies which rely on propane gas to save valuable production time, praise the stop watch accuracy of OIC Valves. Suppliers or users — they're finding that OIC Valves give steady, economical service on *all* propane gas installations.

One of the many utilities in this vitally important field is the Ohio Fuel Gas Company, serving almost half a million customers in a geographical area approximately half the size of Ohio. OIC Valves are installed at both of the company's propane gas plants, with a combined daily capacity equivalent to 65 million cubic feet of natural gas. These plants with 110 tanks (each 30,000 gallons water capacity), are at the company's 70-tank Mt. Sterling Station and the company's 40-tank McMahon Compressor Station near Toledo, Ohio.

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If you don't have OIC's pace-setting valves installed on your lines — *no matter what the service* — switch to OIC! You'll find the right valve with the right trim for your specific job, in OIC's complete, long line of valves. Discover for yourself such exclusive features as the patented gland and gland flange that makes repacking of the stuffing box easy . . . seat rings of the modern end seated type for smooth operation — positive seating and long life . . . the special condensation chamber that protects the packing in high-temperature service. Discover, like hundreds of other companies, that it pays to invest in the best in valves. That means OIC!

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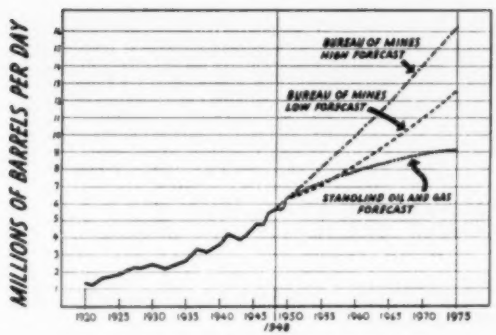
MILLIONS OF BARRELS PER DAY
BUREAU OF MINES HIGH FORECAST
BUREAU OF MINES LOW FORECAST
STANOLIND OIL AND GAS FORECAST
1920 1925 1930 1935 1940 1945 1950 1948 1955 1960 1965 1970 1975

Figure 5. Comparison of Forecasts of U. S. Daily Demand

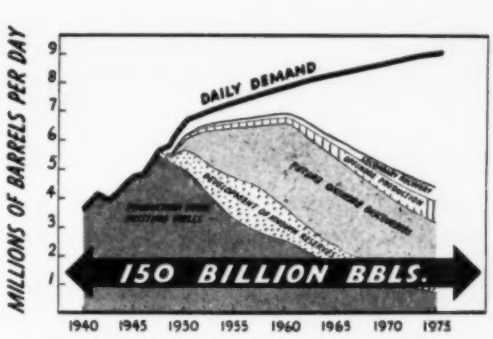

Figure 6. U. S. Demand and Supply Sources Except Imports and Synthetics

case. The costs of manufacturing finished products from crude shale oil are materially higher than the costs of manufacturing finished products from crude petroleum. In their present form, the Bureau's statements are misleading. The resulting confusion could be largely eliminated if the Bureau would more thoroughly explain how it arrived at its cost figures.

Accepting Stanolind's evaluations as the present economic status, it is immediately apparent that a synthetic industry is far from being competitive today. While our figures show that direct costs are not greatly out of line, the addition of investment charges makes synthetics decidedly uneconomic. Only if the government furnished all the capital necessary would it be possible to enter into a commercial synthetic fuel program now. If such a course is taken, the cost to the taxpaying public would be huge.

Barring subsidies, however, these fuels will become realities only when petroleum can no longer supply the nation's total demand for liquid fuels, or when developments reduce costs to competitive levels.

A forecast of our future demands involves a long-range analysis and is done by considering certain significant trends in our economy including growth of our population, increasing use of automobiles, and other motor vehicles, our rising standard of living and the decentralization of cities and industries.

From these trends we can estimate the increase in the number of motor vehicles between now and 1975. To reveal probable gasoline consumption, other factors must be included. While the average milage per car will continue to increase, more efficient motors will tend to keep gasoline consumption per car from rising much above today's level.

Results of these calculations for total gasoline demands during the next quarter century are estimated to reach 1,100,000 barrels per day above present rates. (Figure 3.)

Using various forecasting methods, the consumption of other fuels and lubricants for airplanes, tractors, locomotives, miscellaneous light-duty power equipment and heavy-duty machinery are estimated as are future needs for domestic and industrial heating fuels, greases, waxes and other petroleum products.

When all these requirements are totaled, the demand curve in Figure 4 results. By 1965 the nation will require 8.4 million barrels of petroleum per day, by 1975 9.1 million barrels per day.

Last May the Bureau of Mines estimated that demand for oil in 1975 will be from 12.7 to 16.4 million barrels per day—or 2 to 2½ times the present demand.

Figure 5 compares our forecast of demand with those prepared by the Bureau of Mines. The Bureau's figures appear far too high. It can hardly be expected that demand will keep going up at an increasing rate over such a long period. To reach such levels we must assume every use of petroleum will more than double, or that radically new uses will be found. Actually, the nation will reach the saturation point in many petroleum uses before that time. For instance, passenger cars will not double between now and 1975, even if the population reaches the largest estimate forecast by the Census Bureau. Other uses are already nearing a saturation point. For example, the nation now has one tractor for every 105 acres of tillable land.

If the nation's demand will rise to over 9 million barrels a day, as our forecasts show, how can these needs be supplied? These requirements can be filled in two ways: by crude petroleum, both domestic and foreign, and, when necessary, by synthetics from other raw materials.

For the immediate future as least, domestic petroleum will serve as the nation's major supply. This production will come from five sources—from existing wells, from the development of known but undrilled reserves, from future onshore discoveries, from future offshore discoveries and from secondary recovery.

Production from the first of these domestic sources—existing wells—is declining at a regular rate, a decline characteristic of the average oil well for the past 25 years. On this basis, present active wells will produce another 28 billion barrels of oil by primary recovery. This estimate agrees quite well with that of the API, which predicted these reserves at 26.8 billion barrels as of January 1, 1949. (Figure 6.) Abnormal rates of production decline occur because curtailed market demands are expected to continue for about six more years.

The next domestic source—known but undeveloped reserves— are expected to add another 10 billion barrels to the nation's ultimate recovery. These reserves will increase future supplies as indicated by the additional area in Figure 6.

Next, future onshore discoveries can be estimated by correlating exploratory effort and cumulative oil discoveries. This correlation shows that in spite of technical progress, the industry's degree of success in wildcatting has declined through the years. New reserves discovered have been progressively smaller. Considering these factors, it is estimated that new onshore discoveries will increase our supply by 35 billion barrels. The rate at which this oil will be produced after it is discovered is shown as the third addition to the Figure 6 supply curve.

Added together, the total remaining onshore reserves which we can recover by primary methods equals 73 billion barrels. The nation's production to date has been 37 billion barrels. Thus, our total ultimate primary recovery onshore is expected to be 110 billion barrels. Other methods of estimating these reserves yield results which do not vary substantially from this 110-billion-barrel figure.

Production estimates from submerged coastal lands are difficult to make at this stage of development. By analyzing recoverable reserves on adjacent shore areas, however, it is possible to evaluate the oil-producing potential of offshore structures and say that we expect 20 billion barrels can be recovered from the continental shelf. The rate at which the industry can produce from offshore reserves will depend to a great extent on how soon the question of titles to offshore leases can be settled. The rate indicated here assumes that this issue will be settled in the next two years.

Finally, production in the United States should include the oil which can be obtained by secondary recovery methods. Present day secondary recovery reserves have been estimated by the Interstate Oil Compact Commission to be approximately 8 billion barrels. In the future, secondary recovery measures will be applied to fields not now included in this figure, and additional production will be obtained. As time goes on, these techniques will be applied immediately in the development of new fields under sound engineering practice. Altogether, we estimate that secondary recovery should add 20 billion barrels to the nation's supply. This forecast is based only on today's methods.

From the five domestic sources, therefore, total ultimate crude production in the United States, onshore and offshore, is estimated to be 150 billion barrels. Of

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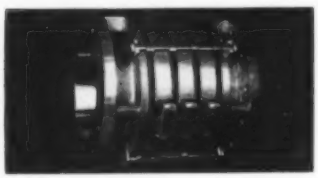

each other by a space equal to the traverse which each corrugation can absorb. When an expanding pipe line exerts a thrust against the end fittings of the expansion joint, each corrugation is partly compressed, but as soon as one corrugation has taken up its share of the movement, the rings on each side bear upon each other, and prevent that corrugation from being further compressed; all the thrust being transmitted to the other corrugations through the equalizing rings. The rings also support the element against internal pressure.

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this total, 37 billion barrels have already been produced.

So far, our estimates show that during the next decade, future domestic production will begin to fall short of meeting our growing requirements (Figure 7). Note that American oil production will reach a maximum rate of 7.1 million barrels a day by 1958. It will drop to a rate of about 6 million barrels in 1965, then taper off to 4.7 million barrels a day by 1975. Figure 7 shows graphically how the gap between domestic supply and demand grows as time goes on.

A large part of these deficits can be filled by imports from the Western Hemisphere. To estimate how large these imports will be, we analyzed the supply and demand for Canada, Central and South America, using techniques similar to those employed for the United States. These areas will continue to produce more crude than they will use, and we can assume that their growing surpluses can be exported to the U. S. (See on Figure 8.) Consequently, we estimate that the U. S. can increase its imports from the rest of this hemisphere from about 500,000 barrels a day in 1950 to 830,000 barrels in 1960 and 2.9 million barrels in 1975. Thus, domestic production plus these imports can supply all of our demands for oil for at least another 10 years.

Oil imports from the Middle East will probably continue at the present low level through 1960. After that time, all demands which cannot be filled by domestic and Western Hemisphere production could be supplied indefinitely from the Eastern Hemisphere.

In the interests of national or hemispheric security, the government may limit imports from that zone. Such a limit is assumed to be approximately 250,000 barrels a day, a quantity which represents a relatively small fraction of the national supply. In the event that these small imports were suddenly cut off, the economy of this country would not be seriously injured. A minor curtailment of civilian consumption could easily offset this loss.

When imports from the Eastern Hemisphere are combined with all other supplies, it will be noted that all needs for oil are filled until 1961, but after that time a growing gap between supply and demand becomes evident. (Also shown on Figure 8.) By 1965, that deficit will be 420,000 barrels a day and will increase to 1,260,000 barrels by 1975. On the basis of these forecasts, it now seems plain that the nation has at least until 1961 before it needs to turn to coal and oil shale to supply any of our liquid fuel demands. There is nothing, therefore, to indicate that we should begin the construction of synthetic fuel plants immediately.

All estimates presented here have been developed on what is believed to be a conservative basis. In so doing, forecast of production have been kept to the lowest level possible. If future supplies actually prove to be greater, if the nation is actually more successful in finding new oil reserves than now estimated, or if greater recovery can result from methods still undiscovered, the necessity for synthetic fuels would be postponed beyond the forecast date of 1961.

Certainly, the importance of work to improve and develop new recovery methods cannot be over-emphasized. For, if research can increase oil recovery by as little as a few percentage points, ultimate recovery will be considerably larger than the 150 billion barrels believed possible under present methods.

Demand estimates have been kept on the high side. Later on, if the oil requirements of the American public actually prove to be less than estimated, crude could supply our needs for a longer time, and synthetics could be deferred beyond 1961.

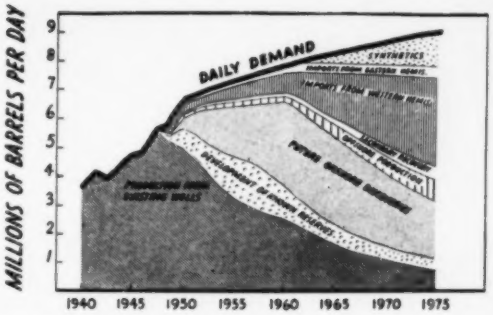


Figure 8. U. S. Demand and Supply

The possibility of some national emergency between now and 1961 should also be considered. Estimates of wartime petroleum needs differ widely. But even if demands reach the highest estimates that have been publicized, the demands of the armed services can be met in whole or in large part by curtailing civilian uses. This is particularly true if our peacetime petroleum economy continues to grow, as all signs indicate that it will. The enlarged producing and refining capacities necessary to meet these growing needs will automatically create a larger supply pool from which emergency stocks could be diverted. But if a national emergency would prove to be so acute that we could not supply military needs through rationing, these stocks could then be supplied by at least three other methods: 1) additional capacity in producing and transportation as well as refining facilities; 2) stockpiles of critical products, such as alkylate or toluene; or 3) synthetic fuel plants.

Recent discoveries in Canada and curtailed production in this country indicate that it should be possible to maintain excess crude producing capacity, at least for the immediate future. Similar excess capacity served us well in the last war. Additional refining capacity would call for a heavy investment, but this would cost less than would synthetic fuel plants. The technology of refining has reached such an advanced state of development that refineries would not be out-dated in a 5 or 10-year period. In contrast, the technology of synthesis from coal and shale is in such an early stage of development that synthetic fuel plants would rapidly become obsolete.

So, in an emergency, oil requirements can best be filled, first by rationing, and second, *if necessary*, by building excess refining, transportation and producing capacity. Stockpiles of critical materials represent additional steps toward preparedness. Together, these measures should meet any crises for oil in the immediate future. Consequently, even for emergency reasons, a synthetic fuel industry would represent a costly expedient for at least another decade.

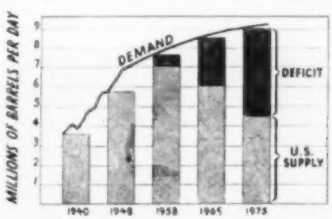


Figure 7. Domestic Production vs. Total Demand

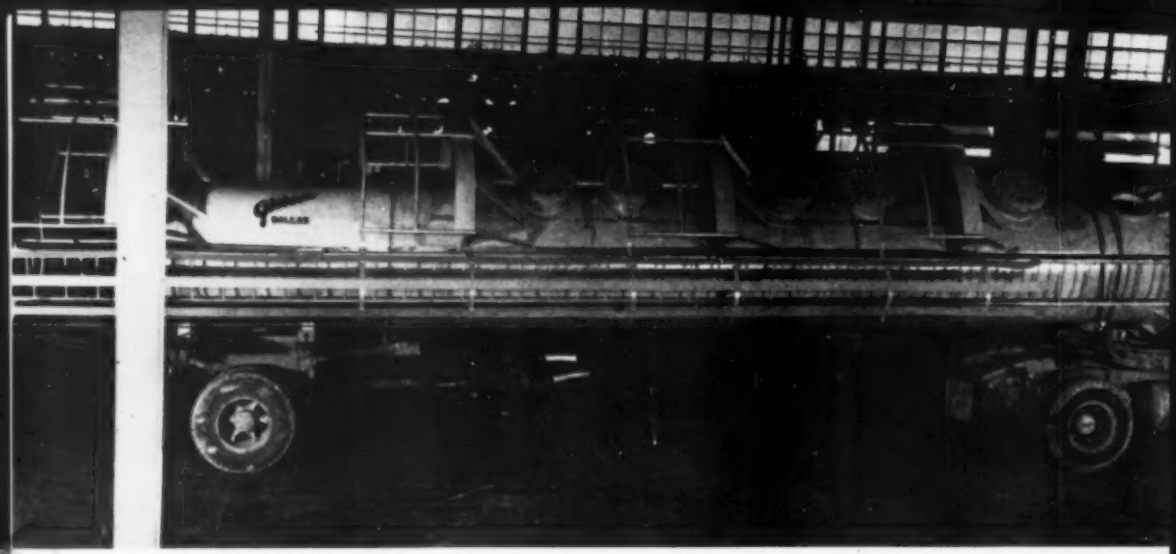
Still another important consideration should postpone a synthetic plant construction program. From what is known about the current technology of synthetic fuels from coal and shale, it is recognized that research can greatly improve present designs. Research can lower the prohibitive costs which now prevail and, by so doing, put today's designs into an outmoded category. As instruments for research, full-scale plants or so-called "demonstration" plants are at best clumsy tools. On the other hand, a flexible pilot plant, costing but a fraction of a commercial plant, can furnish design data easily and efficiently. Each phase of the process can be varied to solve whatever problems may arise.

Obviously, the nation has much to gain if it is not forced to freeze designs as long as development is at its present immature level. Work is going forward on many improvements in design of coal synthesis plants. If research can perfect only those improvements which have an even chance of success, the costs of making gasoline synthetically from bituminous coal can be reduced from 22½ cents per gallon to 17 cents. This 5½-cent reduction would go a long way toward making the process competitive. In passing, it should be noted that the gap between synthetic and crude will be narrowed still further if crude prices rise gradually as we expect them to.

As long as synthetic fuels are more expensive than products from crude, there will probably be proposals to support a synthetic industry with government subsidies. Perhaps the general public does not appreciate the staggering costs involved. Our estimates indicate that investment per daily barrel of gasoline from bituminous coal would be $13,900. A daily capacity of a million barrels would cost the public almost $14 billion, or about $100 for every person in the country. In the end, the general public would have to pay that sum through increased taxes.

Government subsidies also have other detrimental effects. Such doles encourage the retention of uneconomic practices by removing the incentives for competitive development. Thus, by dis-

• CONTINUED ON PAGE 238



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The tabulation appearing below, and on five additional pages, is a regular PETROLEUM REFINER feature which during the more than two years it has appeared has filled a definite need in the processing industry.

To the end that the tabulation appears correct and complete each month, readers are asked to 1) send in "boxscore" data (as called for by the column headings) on projects not listed; 2) furnish details which are missing in any item in the current tabulation and 3) report from time to time on the progress of these projects.

Such cooperation, of tremendous aid in keeping the tabulation continuously up to date, will be much appreciated.

Address Editor, Petroleum Refiner, Box 2608, Houston 1, Texas.

REFINERY AND OTHER PLANT CONSTRUCTION

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
E. I. DuPont	Parkersburg, W. Va.	Tetrafluoroethylene Resin Plant			Under Constr.	Summer, 1950			
Esso Standard Oil	Bayonne, N.J.	Dewaxing	7,500 bbls.		Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
Esso Standard Oil	Bayonne, N.J.	Steam Boilers	400,000 lbs. hr.		Under Constr.	2nd Qtr., 1950		S.O.D., Day & Zimmermann	S.O.D. & Zimmermann
Freeport Sulphur Co.	Westville, N.J.	Sulfur Recovery	40 tons		Contracted				Girdler
Gulf Oil Corp.	Philadelphia, Pa.	Topping, Vacuum	30,000 bbls.		Completed			Lummus, Badger	Lummus
The Pure Oil Co.	Savannah, Ga.	Lube Bld. Plg.			Under Constr.	Nov., 1949			
Quaker State Oil Refining Corp.	Emlenton, Pa.	Boiler Plant Add.	65,000 lbs. hr.	$160,000	Under Constr.	Nov., 1949			Staff
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Dist. Unit	19,500 bbls.		Under Constr.	Fall, 1949		Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Propane Deasph.	5,950 bbls.		Under Constr.	Jan., 1950	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	2,050 bbls.		Under Constr.	4th Qtr., 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Light Oil Trtng.	28,000 bbls.		Designing	Dec., 1949		Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Mod. Comp. Pkg. Dept.	5,000 bbls.		Under Constr.	Jan., 1950		Staff	Staff
L. Sonneborn Sons	Petrolia, Pa.	Antipollution		$400,000	Under Constr.	1st Qtr., 1950		Chemico	Knowles
Sun Oil Co.	MarcusHook, Pa.	Comp. & Pkg.			Under Constr.	Nov., 1949		Staff, Lindsay	W. W. Lindsay
The Texas Co.	Beacon, N.Y.	Expand Research Labs.			Under Constr.	Dec. 1, 1949		Voorhees, Walker, Foley & Smith	

Photo at top of page—New construction at Continental Oil Company's Ponca City, Okla., plant

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
The Texas Co	Westville, N.J.	New Refinery	40,000 bbls.		Under Constr.	Dec. 18, 1940		Foster Wheeler, Jackson-Moreland, Kellogg	Foster Wheeler, Kellogg
United Refining Co	Warren, Pa.	Lab. Steam Gen.	60,000 lbs. hr.			4th Qtr., 1950			Union Iron Wks.
U.S. Dept of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant	1-2 bbls.	$150,000	Under Constr.	Nov., 1940		Staff	Blaw-Knox Co.
MID-CONTINENT									
Ashland Oil & Refining	Canton, Ohio	Ref. Modern.							Cat. Constr.
Champlin Refining Co.	Enid, Okla.	Crude Unit	18,000 bbls.	$600,000	Under Constr.	Nov., 1940		Koch	Staff
Champlin Refining	Enid, Okla.	Cat Poly Unit	450 bbls.	$200,000	Under Constr.	Nov., 1940	U.O.P.	Koch	Staff
Cities Service, Del	Cicero, Ill.	Compound Plt.	1,200 bbls.	$4 million	Contracted	July, 1950			Sollitt
Cooperative Ref. Assn.	Coffeyville, Kan.	Dewaxing	2,200 bbls.	$1.5 million	Contracted	Nov., 1940	Texaco	Process Eng.	Process Eng.
Continental Oil Co.	Ponca City, Okla.	Crude Dist. Unit	32,000 bbls.		Under Constr.	4th Qtr., 1940		Bechtel	Bechtel
*Continental Oil	Ponca City, Okla.	Perco Liquid Copper Treter.	20,000 bbls.		Completed				Cat. Constr.
Deep Rock Oil Corp	Cushing, Okla.	Cat. Cracker	5,000 bbls.		Under Constr.	Spring, 1950		U.O.P.	J. & L. Constr.
The Derby Oil Co	Wichita, Kans.	Cat. Crk.Change			Planning				
Dewey Oil Co	Weston, Ohio	Lube Filtering	250 bbls.	$15,000	Under Constr.	1940		Staff	Staff
Ethyl Corp	Ferndale, Mich.	Batch Gasoline Distil. Units	1 to 3 bbls.		Contracted	4th Qtr., 1940		Rust Pro.	Rust Pro.
Globe Oil & Ref. Co	Lemont, Ill.	Cat. Cracker	6,000 bbls.	$1 million	Buying Material	Jan. 1, 1950	U.O.P.	U.O.P.	
Gulf Oil Corp	Kiefer, Okla.	Gaso. Plant	14,500 mcf		Under Constr.				
Gulf Refg. Co.	Cincinnati, Ohio	Fluid Cat. Crk.	15,500 bbls.			4th Qtr., 1940		Kellogg Stacey, Dresser	Kellogg
Hoosier Gas Corp.	Vincennes, Ind.	Desulfo Unit	3,000 mcf					U.O.P.	Staff
Indiana Farm Bureau Cooperative Assn.	Mt. Vernon, Ind.	Fluid Cat. Cracking Unit	4,000 bbls.		Design				
Lever Bros. Co.	Hammond, Ind.	Hygirtol Plant	150,000 stf		Under Constr.	Jan. 1, 1950		Staff	Girdler
M. F. A. Oil Co	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	Under Constr.	4th Qtr., 1940	Phillips	Koch	Koch
Magnolia Pet. Co	Grant County, Kans. (Hiekok)	Gasoline Plant	100,000 mcf		Under Constr.	Jan., 1950		Staff, Waleo	Waleo
Magnolia Pet	Chitwood, Okla.	Pressure Maint. & Cycling	24,750 mcf		Under Constr.	Dec., 1940		Staff, Constr. Service	Constr. Service*
Magnolia Pet	Stephens County, Okla.	Gasoline Plant	30,000 mcf		Under Constr.	Jan., 1950		Staff, J. & L. Constr.	J. & L. Constr.*†
Midland Cooperative Wholesale	Cushing, Okla.	Cat. Poly Unit	200 bbls.		Authorized	Early 1950			Ref. Eng. U.O.P
Northern Natural Gas Co.	Buston, Kans.	Inc. Comp. Cap.	1,600 hp.		Under Constr.	1940			Dresser
Northern Nat. Gas	Clifton, Kans.	Compress. Add.	1,600 hp.		Under Constr.	1940			Fluor
Northern Nat. Gas	Mullinville, Kans.	Inc. Comp. Cap.	3,200 hp.		Under Constr.	1940			Dresser
Northern Nat. Gas	Sublette, Kans.	Gasoline Plant	265,000 mcf		Authorized	1950			Pritchard
Northern Nat. Gas	Sublette, Kans.	Increase Comp.	3,200 hp.		Under Constr.	1940			Fluor
Oklahoma Refg. Co	Seminole, Okla.	Refinery	200 bbls.	$40,000		4th Qtr., 1940			
Old Dutch Refg. Co	Muskegon, Mich.	Platforming Unit	2,000 bbls.		Under Constr.	4th Qtr., 1940	U.O.P.	U.O.P.	Staff
*Pan-Am. Southern Corp.	El Dorado, Ark.	Delayed Coke Water Cooling Tower, Steam Gen. Boiler, Coke & Loading	9,300 bbls.		Planning	Sept., 1950		Lummus	Lummus
Petco Corp	Blue Island, Ill.	Houdri, Cat. Crk., LPG Recov.	5,000 bbls.	$400,000	Under Constr.	4th Qtr., 1940	Houdry	Houdry	Clarke
Phillips Pet. Co	Kansas City, Mo.	Cat. Crack	24,000 bbls.	$10 million	Under Constr.	Nov., 1940		Braun	Braun
		Cat. Poly	1,500 bbls.						
Phillips Pet., et al	Edmond, Okla.	Absorp. Plt. Add.	60,000 mcf		Authorized	April, 1950			Ref. Maint.
The Pure Oil Co	Toledo, Ohio	Revamp. Crd. Reform.			Under Constr.	1940			Cat. Constr.
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Under Constr.	April, 1950	Perco	Koch Eng.	Koch Eng.
Skelly Oil Co	Eldorado, Kans.	Crd. Dist. Cat. Crk.	35,000 bbls	$8-10 million	Under Constr.	Mid 1950			
Socony-Vacuum	E. St. Louis, Ill.	Crude Distil.	15,000 bbls.		Under Constr.	4th Qtr., 1940		Staff	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Thermal Crack	13,200 bbls.		Under Constr.	Jan., 1950		Staff	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Miscl. Ref. Addls.			Under Constr.	Jan., 1950		Staff, Bechtel	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Delayed Coking	8,700 bbls.		Under Constr.	March, 1950		Staff, Bechtel	Bechtel
Socony-Vacuum	Augusta, Kans.	Houdry Conversion to T.C.C.	15,000 bbls.		Planned	Mid., 1950	Socony-Vacuum		
Socony-Vacuum	Trenton, Mich.	Houdry Conversion to T.C.C.	15,000 bbls.		Planned	Mid., 1950	Socony-Vacuum		
Standard Oil Co., (Indiana)	Whiting, Ind.	Outside Battery Limit Facilities			Under Constr.	1940		Fluor	Fluor
*Standard Oil Co. (Ohio)	Cleveland, Ohio	Houdry Cat. Change		$450,000	Under Constr.	Jan., 1950			
Standard (Ohio)	Lima, Ohio	Inc. Tank. Cap.	384,000 bbls.	$240,000	Under Constr.	May 1, 1950		Staff	Hammond
Standard (Ohio)	Lima, Ohio	Liquid Gas Plt.		$220,000	Under Constr.	Dec. 31, 1949		Staff	Undetermined
Standard (Ohio)	Lima, Ohio	Furfural Refg.	76,000 gals.	$13 million	Contracted	1951	Texaco	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Cat. Cracking	16,000 bbls.	$11 million	Completed		U.O.P.	McKee	McKee
Standard (Ohio)	Lima, Ohio	Crd. Dist. Coke	†15,000 bbls.	$5.5 million	Under Constr.	Feb., 1950	Kellogg	Kellogg	Kellogg
Standard (Ohio)	Lima, Ohio	Solvent Dewax.	1,800 bbls.		Under Constr.	Mid., 1950	Texaco	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.		Under Constr.	Mid., 1950			Lummus
Standard (Ohio)	Lima, Ohio	Propane, Desaph.	800 bbls.		Under Constr.	Mid., 1950			Kellogg
Sun Oil Co	Toledo, Ohio	Cat. Crack. Crude Dist., Vac., Poly	30,000 bbls.	$18 million	Under Constr.	Jan., 1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil	Toledo, Ohio	Compressor Sta.	3,840 hp.		Designing			Fluor	
The Texas Co	W. Tulsa, Okla.	Expand. Modernize Refinery	30,000 bbls.	$15 million	Under Constr.	Dec., 15, 1949		Kellogg, Foster Wheeler, U.O.P.	Kellogg, Foster Wheeler
The Texas Co	Lawrenceville, Illinois	Expand Refinery	†20,000 bbls.		Design	April 1, 1951		Foster Wheeler, Kellogg	Foster Wheeler, Kellogg
Tide Water Associated Oil Co.	Drumright, Oklahoma	Houdriflow Unit Cat. Cracker	4,500 bbls.		Under Constr.	Late 1949	Houdry		Process Eng.
U. S. Dept. of Interior	Louisiana, Mo.	Demonstration oil-from-Coal	80 bbls.	$5 million.	Under Constr.	Dec., 1940		Koppers	Koppers
Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Fluid Cat. Cracker	7,500 bbls.	$2.5 million	Under Constr.	Dec., 1940	U.O.P.	Koch	Staff
Wood River Oil R	Hartford, Ill.	Vacuum Unit	15,000 bbls.	$700,000	Under Constr.	1940		Koch	Staff
SOUTHWEST									
Alba Refg. Co	Alba, Texas	Asphalt Refining	1,500 bbls.	$125,000	Under Constr.	Nov., 1940			
Amarillo Oil Co	Exell, Texas	Compressor Sta. Exten.	600 hp.		Under Constr.	4th Qtr., 1940		Staff	Bowden
Anzac Oil Corp	No. Coleman County, Texas	Gas-injection	500,000 cf		Postponed				
Barnsdall Oil Co	Placedo, Texas	Compressor Sta.	2,000 hp.	$380,000	Completed			Olsen	Olsen

• BOXSCORE CONTINUED ON PAGE 91

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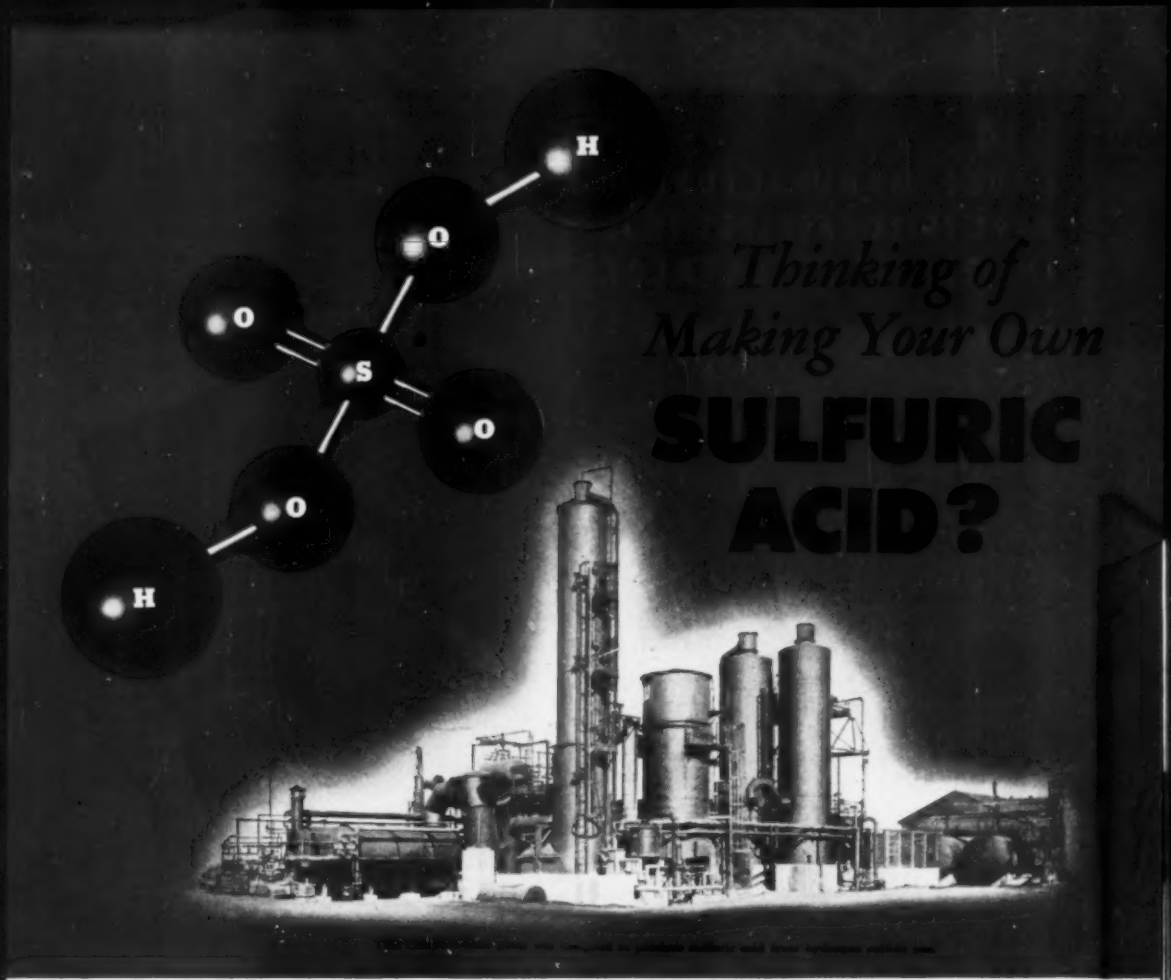
REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Calumet Refg. Co.	Princeton, La.	Blending Oil Tank House	700 bbls.		Under Constr.	1st Qtr., 1950		Staff	Staff
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$26 million	Under Constr.	Dec., 1949	Hydro-Res., Inc. Texaco	McKee, Hyrdo-Res., Inc.	McKee
Cities Service Oil	Chico Field, Tex.	Natural Gasoline	22,000 mcf		Designing	Early 1950		Fluor	Fluor
Cities Service Oil	St. Rose, La.	Lube Oil Blending	1,500 bbls.	$750,000	Under Constr.	Late 1949		Day & Zimmerman	Day & Zimmerman
Coastal Refineries, Inc. & Mayfair Minerals, Inc.	McAllen, Texas	Cycling Plant	75,000 mcf		Under Constr.	Mar., 1950		Gasc. Plant	Gasc. Plant
Continental Oil Co.	McAllen, Texas	Gasc. Plant	20,000 mcf	$1.5 million	Under Constr.	Dec., 1949			J. & L. Constr.
Continental	Big Lake, Todd (Deep) Field, Texas	Gas Recovery Plant	10,000 mcf	$3 million	Under Constr.	Nov., 1949		Ref. Maint.	Ref. Maint.
Continental & Assocs.	Near Nordheim, DeWitt County, Texas	Gas Comp.	12,000 mcf	$1 million	Planning	Dec., 1949	None	Process Eng.	Process Eng.
Cosden Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plt.	6,000 bbls.	$2 million	Under Constr.	Nov., 1949	U.O.P.	U.O.P.	Ref. Eng
Del Rey Petroleum Co.	Chesterville, Colorado County, Texas	Pressure Absorption Plant	25,000 mcf		Under Constr.			O. L. Olson	Ole Olson
Department of the Army	Houston, Texas	Anhydrous Ammonia Facility	2,100 tons monthly	$2.5 million	Relocating	4th Qtr., 1949		Girdler Corp.	Hercules Powder Co.
Dow Chemical Co.	Freeport, Texas	Ammonia Plant	100 tons	$5 million	Planning	Late 1950			
*Dow Chemical	Freeport, Texas	Chlorine Addition			Under Constr.	Late 1949		Staff	Tellepsen
El Paso Natural Gas Co.	Mohane Field, Texas	Gasoline Plant	16,700 mcf		Designing	Nov., 1949		Fluor	Staff
El Paso Natural Gas.	Mohane Field	Treating Plant			Designing	Late 1949		Fluor	Staff
El Paso Natural Gas.	Moore County, Texas	Compressors	10,600 hp.	$1.8 million	Under Constr.	Jan., 1950		Staff	
El Paso Natural Gas.	Moore County, Texas	Gas Dehydration adds.	130,000 mcf	$55,000	Under Constr.	Jan., 1950		Stearns-Roger	Staff
El Paso Natural Gas.	Castro County, Texas	Compressor Sta.	4,050 hp.	$1.1 million	Under Constr.	Jan., 1950		Staff	Staff
El Paso Natural Gas.	Crane County, Texas	Compressor Sta.	4,400 hp.	$1.27 million	Under Constr.	Jan., 1950		Staff	Staff
El Paso Natural Gas.	Extor County, Texas	Compr. Unit	3,200 hp.	$550,000	Under Constr.	Jan., 1950		Staff	Staff
E. I. DuPont de Nemours Co., Inc.	Victoria, Texas	Chemical Intermediate for Nylon			Design	Early 1951		Staff	Staff
Esso Standard Oil Co.	Baton Rouge, La.	Mechanical Shops, Main Office, Cafeteria, Crude Desalting Unit				4th Qtr., 1949 May, 1950		Braun, Harris, Bodman & Murrell, Staff	Braun, Harris, Staff
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities		$40 million	Under Constr.	4th Qtr., 1949		Stone & Webster	Stone & Webster
Gulf Oil	Port Arthur, Texas	Revamp Houdry Fixed-Bed Units	10,000 bbls.		Completed		Houdry	Cat. Constr. Co.	Cat. Constr. Co.
*Hamman Oil Co.	Bay City, Texas	Refinery	2,100 bbls.		Closed Down				
Humble O&R Co.	Katy, Texas	Add Propane, Absorp., Refrig.	Unchanged		Under Constr.	4th Qtr., 1949		Stearns-Roger	Stearns-Roger
Humble O&R	Conroe, Texas	Absorption	30,000 mcf		Under Constr.	4th Qtr., 1949		Stearns-Roger	Stearns-Roger
Humble O&R	Opelousas, La.	Absorption	110,000 mcf		Under Constr.	4th Qtr., 1949		Hudson	Hudson
Humble O&R	Baytown, Texas	Roof Replacing of Butyl Bldg.			Under Constr.			Staff	Staff
Humble O&R	Baytown, Texas	Misel. Facilities		$1 million	Projected				
Humble O&R	Jourdanton Field, Texas	Gasoline Plant	26,000 mcf		Under Constr.	Early 1950			Hudson
Humble O&R	Tomball Field, Texas	Add Compression Facilities	10,000 mcf		Under Constr.	4th Qtr., 1949		Fluor	Fluor
Jefferson Chem. Co., Inc.	Austin, Texas	Central Research Facilities			Under Constr.	4th Qtr., 1949		Staff	Staff
Lone Star Gas Co.	Dallas, Texas	Hypersorption	60 mcf		Design & Eng.	1949	Union Oil Co.	Foster Wheeler	Foster Wheeler
*Magnolia Pet. Co.	Beaumont, Tex.	Two Houdry's to T.C.C.	30,000 bbls.		Authorized	Late 1950			Lummus
Magnolia Pet.	Seelignon Field, Fremont, Texas	Gasoline Cycling, Casinghead	150,000 mcf Cycled 70,000 mcf Casinghead		Under Constr.	Nov., 1949 4th Qtr., 1949		Hudson	Hudson
Mayfair Minerals	McAllen, Texas	Cycling Plant	50,000 mcf		Under Constr.	Mar., 1950		Gasc. Plant	Gasc. Plant
Midland Gasoline Co.	Conroe, Texas	Enlarge Gasoline	100,000 gals.		Under Constr.	Dec., 1949		Gasc. Plant	Gasc. Plant
Northwestern Refining Co.	St. Paul Park, Minn.	Loading Rack, Products Transfer Line	500,000 gals	$40,000	Under Constr.	Jan., 1950		Staff	Staff
Pan American Refining Corp.	Texas City, Tex.	Revamping Crude Unit			Under Constr.	Late 1949		Tellepsen	Tellepsen
*Pan Am. Refg.	Texas City, Tex.	Desulfo Unit		$25,0000	Under Constr.	Early 1950		Tellepsen	Tellepsen
Panhandle Producing & Refining Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Under Constr.	Jan. 1, 1950	U.O.P.	U.O.P., J. & L. Constr.	J. & L. Constr.
Phillips Chemical Co.	Etter, Texas	Prod. of Nitric Acid	225 tons		Under Constr.	Nov., 1949	Chemico	Chemico	Brown & Root
Phillips Chemical	Etter, Texas	Fertilizer Plant	300 tons		Under Constr.	4th Qtr., 1949	Chemico	Chemico	Brown & Root
Phillips Chemical	Borger, Texas	Increase Cap. Phil-black Carbon Black Plant	8 mln. lbs. yr.		Under Constr.	Dec., 1949		Staff	
Phillips Chemical	Etter, Texas	Inc. Cap. Cactus Ammonia Plant	440 tons	$5.3 million	Under Constr.	4th Qtr., 1949	Chemico	Chemico	Brown & Root
Plymouth Oil Co.	Rankin, Texas	Gas Compression, Absorp.	70,000 mcf	$5½ million	Under Constr.	1949-50			Hudson
The Pure Oil Co.	Dollarhide, Andrews County, Texas	Nat. Gasoline Plant	22,000 mcf	$6 million	Under Constr.	July, 1950			
*The Pure Oil Co.	Nederland, Tex.	Barge Dock Repair			Under Constr.	Late 1949		Staff	Tellepsen
*The Pure Oil Co.	Nederland, Tex.	Wax Plt. Add.			Under Constr.	Early 1950		Staff	Tellepsen
The Pure Oil Co.	Nederland, Tex.	Wax Fractnin.	200 bbls.		Under Constr.	4th Qtr., 1949	Texaco	Lummus	Lummus
Reno Oil Co.	Holiday, Texas	Gasc. Press. Maint. Plant	400 hp.		Under Constr.	4th Qtr., 1949	None	O. L. Olson	O. L. Olson
The Shamrock Oil & Gas Corp.	Sunray, Texas	Inc. Top., Crk.	10,000 bbls.	$300,000	Under Constr.	4th Qtr., 1949	U.O.P.	Staff	Staff
*The Shamrock Oil & Gas	Sunray, Texas	Cycloversion Unit	1,500 bbls.	$300,000	Under Constr.	Early 1950	Pereo	Staff	Staff
*Shell Oil Co.	Deer Park, Tex.	Maint. Shop Bldg.		$4 million	Completed				
Shell Oil Co.	Houston, Texas	Lube Utilities			Under Constr.	1949		Fluor	
Shell Oil Co.	Provident City, Texas	Gas Stripping	60,000 mcf		Under Constr.	1st Qtr., 1950		Fluor	Fluor
Shell Oil Co.	Notrees, Texas	Add TXL Plant	30,000 mcf		Under Constr.	Early 1950		Brown & Root	Brown & Root
Shell Oil Co.	Denver City, Texas	Gas Comp. Absorp. Add.	30,000 mcf		Under Constr.	Late 1949		Fluor	Fluor

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Southern Minerals Corp.	Stratton Field, Texas	Gas Compression addition			Under Constr.				
Stanolind O&G Co., Opr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf		Under Constr.	Jan., 1950		J. & L. Constr.	J. & L. Constr.
*Stanolind Oil & Gas Co.	Alvin, Texas	Dehydration, Gas Sales Plt.			Under Constr.	Late 1949		Staff	Tellepsen
Stanolind O&G	Brownsville, Tex.	Chemical Plant	40 mln tons/yr.		Under Constr.	Jan. 1, 1950		Badger	Badger
Stanolind O&G	Levelland, Tex.	Gasoline Plant	40,000 mcf		Under Constr.	Feb., 1950		Brown & Root	Brown & Root
Stanolind O&G	N.Cowden, Tex.	Gasoline Plant	50,000 mcf		Under Constr.	1950		Stearns-Roger	Stearns-Roger
Sun Oil Co.	Starr Co., Tex.	Gasoline Plant	35,000 mcf	$4 million	Under Constr.	4th Qtr., 1949	Pet. Eng.	Pet. Eng.	Pet. Eng.
Sun Oil	Chambers County, Texas	Compressor Plant	14,000 mcf		Under Constr.	Dec., 1949			Pritchard
Sun Oil	Egan, La.	Compressor Plt.	10,000 mcf	$400,000	Authorized	1950			
Tex. Natl. Gas Corp. & Sick-Trachel	Rankin, Texas	Nat. Gasoline Plant	55,000 mcf		Under Constr.	Nov., 1949		Tex. Natl. Gas Corp.	Pritchard
The Texas Co.	Tijerina-Canales Field, Texas	Gas Compression	3,000 mcf		Under Constr.	July, 1950			
The Texas Co.	Chalk-Hill Field, Texas	Gas Compression, Absorp.	2,500 mcf		Completed				
United Gas Pipe Line Co.	Karnes City, Texas	Nat. Gas., Condensate Process	10,000 mcf	$1 million	Under Constr.	Jan., 1950		Delta	Delta
ROCKY MOUNTAIN									
Coronado Gas Corp.	Loco Hills Field, N. M.	Repressuring, Extraction	10,000 mcf	$500,000	Under Constr.	4th Qtr., 1949	P. M. Raigorodsky	Pet. Eng.	Pet. Eng.
Coronado Gas	Artesia, N.M.	Enlarge Plant	10 million gals.	$400,000	Under Constr.	4th Qtr., 1949	Pet. Eng., Inc.	Pet. Eng.	Staff
El Paso Nat. Gas Co.	Lea County, N. M.	Compressor Sta.	5,500 hp.	$1.35 million	Under Constr.	Jan., 1950		Staff	Staff
El Paso Nat. Gas		Gas Purif. Plt.	50,000 mcf	$325,000	Under Constr.	Jan., 1950		Stearns-Roger	Staff
El Paso Nat. Gas		Gaso. Absorp. Plant	50,000 mcf	$285,000	Under Constr.	Jan., 1950		Stearns-Roger	Staff
Empire State Oil Co.	Thermopolis, Wyo.	Crude, Vacuum	5,000 bbls.	$325,000	Under Constr.	1949		Ref. Eng.	Ref. Eng.
*Frontier Refining Co.	Cheyenne, Wyo.	Coking, 2 Coke Crks.	2,400 bbls.	$725,000	Contracted	May, 1950	U.O.P.	Ref. Eng.	Ref. Eng.
Northern Natural Gas Co.	Palmyra, Neb.	Compressor Add.	1,600 hp.		Under Constr.	1949			Fluor
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant			Projected				
Salt Lake Refining Co.	Salt Lake City	Cat. Cracking	25,000 bbls.	$10 million	Design	Jan., 1951		Bechtel-Houdry	Bechtel
Socony-Vacuum Oil Co.	Casper, Wyo.	Topp. Revisions	5,900 bbls.		Under Constr.	Fall, 1949		Staff	Cat. Constr.
Southern Union Gas Co.	Bloomfield, N. M.	Gas-dehydration Unit	60,000 mcf	$40,000	Completed			Graff	
Texas Gulf Sulphur Co.	Worland, Wyo.	Sulfur Recov., Gas Treat. Plts.	30,000 mcf		Under Constr.			Girdler, C. F. Braun, Foster Wheeler	Girdler
WEST COAST									
General Pet. Corp.	Torrance, Calif.	H_2S Absorption			Engineering	Jan., 1950		Badger	Badger
General Pet. Corp.	Torrance, Calif.	Noded Spheroid	2 million gal.	$400,000	Under Constr.	1949		Staff	C.B.&I.
General Pet. Corp.	Torrance, Calif.	Cooling Tower	8,400 gal.		Under Constr.	1949		Staff	Fluor & Staff
General Pet. Corp.	Torrance, Calif.	Chemical Treat.	2,000 tons		Under Constr.	Late Fall, 1949		Staff	Staff
General Pet.	Torrance, Calif.	Two Coke Drums, Furnace	7,500 bbls.	$2.25 million	Under Constr.	Early 1950		Kellogg	Bechtel
Hancock Chemical Co.	Long Beach, Cal.	H_2S Recovery	50 tons	$1 million	Designing	Jan., 1950		Badger	Badger
Hancock Oil Co.	Long Beach	Ethylene Glycol	60,000 lbs.		Engineering	3rd Qtr., 1950		Badger	Badger
Ohio Oil Co.	S. Coles, Levee, Calif.	Gas Lift	1,800 hp.		Under Constr.	Nov., 1949		Fluor	Fluor
Paloma Refining Co.	Paloma Fied, Calif.	Extend Absorption Sect.	60,000 mcf		Planning				
Richfield Oil Corp.	Cuyama, Calif.	Absorption H_2S Removal	15,000 mcf		Under Constr.	1949		Fluor	Fluor
Richfield Oil Corp.	Cuyama, Calif	Comp. Plt. Extn.	2,640 hp.		Designing	1949		Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Add. Crk. Comp.			Under Constr.	1949		Fluor	Fluor
*Shell Oil Co.	Ventura, Calif.	Modernize Nat. Gaso. Plt.			Completed				
Southern Counties Gas Co.	Blythe, Calif.	Add. Compressor Capacity		$350,000	Completed		None	Mel-Mar	Gill
Standard Oil Co. of Calif.	Bakersfield, Cal.	Ther. Crk. Gaso. Stabil., Treat.	9,000 bbls.		Under Constr.	Late 1949	U.O.P.	U.O.P.	Braun
Standard Oil, Calif.	Bakersfield	Crude Dist.	10,000 bbls.	$7.7 million	Under Constr.	Nov., 1949	Braun	Braun	Braun
Union Oil Co. of Calif.	Brea Olinda, Cal.	Research Plant		$5 million	Projected	Sept., 1950			
Union Oil of Calif.	Oleum, Calif	Revise Refg.		$4 million	Under Constr.	Dec., 1949		Parsons, E. & A.	Ref. Maint.
Union Oil of Calif.	Oleum, Calif.	Improve handling facilities		$1.5 million	Under Constr.	Dec., 1949		Mathews, Montgomery	Early, C. N. Peterson, Mathews
Union Oil of Calif.	Oleum, Calif.	Tankage and Utilities		$1.8 million	Engineering	1st Qtr., 1950		Parsons	Eaton & Smith, C.B.&I., Utah
Union Oil of Calif.	Oleum, Calif.	Main Office Addition, Shops, Misc.		$1 million	Under Constr.	Dec., 1949		Austin, Field & Fry, D. R. Warren Co., Montgomery	E. S. McKittrick, Parker, Steffens & Pearce
FOREIGN									
Canada									
British American Oil	Montreal East, Quebec	Cat. Crk., Poly.	13,300 bbls.		Under Constr.	4th Qtr., 1949	Kellogg-U.O.P.	Kellogg	Kellogg
Excelsior Refgs., Ltd.	Lloydminster, Alberta	Cap. Increase	3,000 bbls.		Under Constr.	1950	U.O.P.	U.O.P.	
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Crude Topping Unit	2,000 bbls.		Under Constr.	Dec., 1949	U.O.P.	Ref. Eng.	Ref. Eng.
Hi-Way Refineries	Saskatoon	Thermal Crack.	500 bbls.		Under Constr.	Dec., 1949	U.O.P.	Ref. Eng.	Ref. Eng.
Imperial Oil, Ltd.	Leduc Field	Gas Absorption	24,000 mcf	$6.5 million	Under Constr.	Mid. 1950		Braun	Braun
Imperial Oil	Regina, Saskatchewan	Add Distil. Equip.	3,000 bbls.	$380,000	Under Constr.	Jan., 1950		Staff	Staff
Panther Oil and Grease Co.	Leaside, Toronto, Ontario	Grease and Compounding			Projected				
Shell Oil Co. of Canada, Ltd.	Montreal East, Quebec	Fluid Cat. Crk., Vac. Flash Gas Recov., Poly, Treat.	35,000 bbls.		Under Constr.	Late 1950		Staff	Fluor, Ltd., McKee
Latin America									
*Administracion National Combustible Alcohol y Portland	Montevideo, Uruguay	Lube, Asphalt Units	7,500 bbls.		Under Constr.	1st Qtr., 1950		Foster Wheeler	Foster Wheeler
Conselho Nacional do Petroleo	Mataripe, Bahia, Brasil	Thermal Cracking Refinery	5,000 bbls.	$2.5 million	Under Constr.	Jan., 1950		Kellogg	Kellogg, Staff
Creole Pet. Corp.	Amuay Bay, Venezuela	Crude Stills	60,000 bbls.	$175 million	Under Constr.	1950		S.O.D.	Foster Wheeler, J. G. White

• BOXSCORE CONTINUED ON PAGE 95



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14
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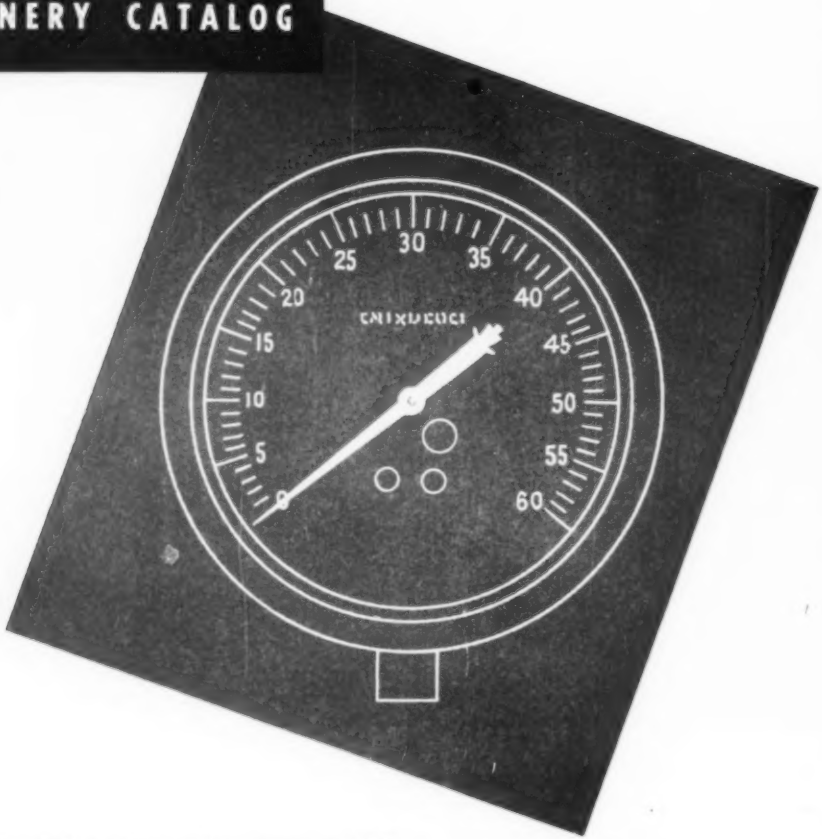

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring			Planning				
Ipiranga S.A. cia Brasilera de Petroleos	Rio Grande, Brazil	Topping, Thermal Cracking	3,000 bbls.		Authorized	1952	Foster Wheeler		
Mene Grande Oil Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.						
Petroleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maint.		$13 million	Contracted	Early 1950		McKee	McKee
Petroleos Mexicanos	Salamanca, Mex.	Crd.,Gasoil, Crk.	25,000 bbls.	$12 million	Under Constr.	Early 1950	U.O.P.	McKee	McKee
Refinaria de Petroleo do Distrito Federal S.A.	Rio de Janeiro, Brazil	Complete Refinery	45,000 bbls.		Authorized				Fives, Lille, Schneider, Staff
Refinaria e Exploracao de Patroleo Uniao S.A.	Capuava, Sao Paulo, Brazil	Thermal Cracking Refinery	20,000 bbls.		Authorized			Pan American Hydrocarbon Res., Inc.	Czech, Fact. Metal Work Mech. Constr.
Richmond Exploration Co.	Bajo Grande, Venezuela	New Refinery	35,000 bbls.		Engineering	June, 1950			
*Shell Caribbean Pet. Co.	La Paz, Venezuela	Gas Plant	90 tons		Under Constr.	Early 1950			
*Shell Caribbean Pet. Co.	Mara, Venezuela	Gas Plant	90 tons		Projected	Early 1951			
Shell Oil of Venezuela	Punta Cardon, Venezuela	Comprehensive Refining	50,000 bbls.	$32 million	Under Constr.	Mid 1951			
Venezuela Gulf Refining Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.	$5 million	Under Constr.	July, 1950		Lummus	Lummus
Venezuelan Pet. Co.	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.		Under Constr.			Snare	Snare
Yacimientos Petroliferos Fiscales	Buenos Aires, Argentina	New Refinery	28,000 bbls.	$54 million	Engineering	Late 1950		Kellogg	Kellogg
YPF	La Plata, Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	1949		Houdry Process Cat. Constr.	Cat. Constr.
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.			3rd Qtr., 1950		Foster Wheeler	Foster Wheeler
Europe and Africa									
Anglo-American Oil Co.	Fawley, Eng.	Refinery Expansion	110,000 bbls.	$150 million	Under Constr.	Late 1952		Foster Wheeler	Foster Wheeler
Anglo-Iranian Oil	Isle of Grain, Eng.	Cent. Refg. Unit	60,000 bbls.	$120 million	Planning	1952	Texaco (Lube Unit)	Lummus	Lummus
Anglo-Transvaal Consolidated Investment Co.	Vall River, Union of South Africa	Synthetic Gasoline and Diesel Oil Plant		$50-60 million	Contracted			Hydrocarbon Research	
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.		Projected	Late 1951			
Azienda Generale Italiana Petroli	Palermo, Italy	Marine Fuel Plant	7,500 bbls.						
Batafsche Petroleum Mij.	Pernis, Holland	P.U.C. Plant	2,000 tons, yr.			Jan., 1950			
My. Batafsche Pet.	Pernis, Holland	Expansion	50,000 bbls.		Under Constr.	Mid 1952			
Cabot Carbon, Ltd. (Godfrey L. Cabot, Inc.)	Ellesmere Port, Eng.	Carbon Black Plant	50,000 lbs., yr.		Under Constr.	1950		Simon-Carves, Ltd.	Simon-Craves, Ltd.
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Complete Refinery	20,000 bbls.	$18 million	Under Constr.	Feb., 1950		McKee, Badger, U.O.P.	McKee
Cie. de Raffinage Shell-Berre	Berre, France	Expansion	40,000 bbls.		Under Constr.	Mid 1951			
Shell	Petit-Couronne	Teepol Plant	25,000 tons, yr.			Mid 1950			
Cie. de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit			Planned				
Cie de Raffinage Shell-Berre	Petit-Couronne (Rouen), France	Expansion	10,000 bbls.		Under Constr.	Early 1950			
Cie. Francaise de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.		Projected	1951	Texas	Kellogg-Lummus	
Cie. Francaise de Raffinage	Gonfreville, France	Distillation Unit	20,000 bbls.		Under Constr.	1950		Foster Wheeler	Foster Wheeler
Cie. Francaise de Raffinage	Provence, France	Topping Unit	20,000 bbls.	$11 million	Under Constr.	1950		Foster Wheeler	Foster Wheeler
Cia. Espanola de Petroleos S.A. C.E.P. S.A.	Canary Islands, Spain	Furf. Ref. Sol. Dewax., Wax Fractntn.	5,000 bbls.	$4.5 million	Under Constr.	Early 1950	Texaco, Standard, N.J.	Foster Wheeler	Foster Wheeler
*Condor, S.P.A. Per l Industrial Pet. e Chemica	Rho, Italy	New Refinery	1 mln tons yr.						
Danish Government	Denmark	Refinery	21,000 bbls.		Planned				
Egyptian Government	Cairo, Egypt	Crude Plant						Lummus	Lummus
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.						
Industria Nazionale Petroli e Trasformazione	Massa Carrara, Italy	Refinery	40,000 bbls.			Late 1951			
Industria Petrolifera e Chimica	Milan, Italy	Gasoline Fuel Oil Plant	20,000 bbls.					Dr. Calogero Inglogio	
Imperial Chemical Industries, Ltd.	Wilton, Yorkshire, England	Petroleum Cracking Unit			Under Constr.	1950		Kellogg	Kellogg
Kopparfrans Co.	Goteborg, Swe.	Crd. Ther., Crk.	12,500 bbls.		Under Constr.	4th Qtr., 1949		Lummus	Lummus
Stand.-Azienda Gen. Indro. Comb. (Stanic)	Leghorn, Italy	Add Capacity	28,700 bbls.						
Ditto (Stanic)	Bari, Italy	Add Capacity	38,300 bbls.						
L'Alliance Petrofina.	Antwerp, Belg.	Refinery	21,000 bbls.		Planned				
Manchester Oil Refinery, Ltd.	Partington, England	Cat. Crk., Lube Reforming	20,000 bbls.		Projected				
Monsanto Chemica Co.	Britain	Add Polystyrene			Design	Early 1950		Staff	Staff
National Oil Refineries, Ltd.	Llandarcy, Wales	Crude and Reform	40,000 bbls.					Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Furf. Ref. Sol. Dewax, Wax Fractn.	1,200 bbls.	$36 million	Designing		Texaco	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.		Contracted			H.W.P.	
Pechelbronn, S. A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.		Authorized	1950			
Petro Carbon, Ltd.	Partington, England	Cat. Cracker, Lube & Reform	20,000 bbls.						
Petro Chem., Ltd.	Partington, England	Petro Chemicals	2,000 bbls.	$16 million	Under Constr.	1949	Petro-Carbon	Petro-Carbon	Petro-Carbon
Philblack, Ltd.	Avonmouth, England	Carbon Blk. Plt.	137,000 bbls.	$5 million	Contracted	1950	Phillips	H.W.P.	H.W.P.
Porto Marghera Refg.	Venice, Italy	Enlarge Crd.			Contracted			H.WP.	H.W.P.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Raf. de Pet. de Escom, S.A.	Cartagena, Spain	Refinery	20,000 bbls.	.....	Under Constr.	July, 1951	.....	.....	.....
Raffinerie Belge de Petroles S.A.	Antwerp, Belgium	Therm. Crk., Reform., Gas Plant	.....	$2 million	Under Constr.	Late 1949	.....	Barnes	Barnes
Raffineries de Petrole de la Gironde	Bec Ambes, France	Refinery	13,000 bbls.	$7.8 million	Reconstr.	Early 1950	.....	U.O.P., McKee	McKee
Raffineries Francaises de Petrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	$9.4 million	.....	.....	.....	.....	.....
Raffineria di Napoli, S.P.A.	Naples, Italy	Visbreaker	.....	.....	.....	Early 1950	.....	Staff	Staff
Raffineria di Napoli, S.P.A.	Naples, Italy	Topping Unit	15,000 bbls.	.....	Under Constr.	Late 1949	.....	Staff	Staff
Raffineria di Napoli.	Naples, Italy	Solvent Treating	1,000 bbls.	.....	Under Constr.	Dec., 1949	Texaco	Staff	Staff
Raffineria di Napoli.	Naples, Italy	Reformer	5,000 bbls.	.....	Under Constr.	Early 1950	.....	Staff	Staff
Raffinerie Siciliane Olii Minerali, S.A.	Agusta, Sicily	Crude Refinery	10,000 bbls.	.....	Designing	Early 1950	U.O.P.	U.O.P., Delta	S. T. I. I.
Scottish Oils, Ltd.	Grangemouth, Scotland	Crude	28,000 bbls.	$28 million	Designing	.....	.....	Kellogg	Kellogg
Scottish Oils, Ltd.	Grangemouth	Cat Crk.	5,000 bbls.	.....	Planned	.....	.....	.....	.....
Shell Chemical Mfg. Co., Ltd.	Thornton, Eng.	Teepol Plant Extension	75,000 tons per Year	.....	Under Constr.	Jan., 1950	.....	.....	.....
Shell Refining & Marketing Co., Ltd.	Stanlow, Eng.	Comprehensive Refining	60,000 bbls.	.....	Under Constr.	Early 1952	.....	.....	.....
Shell Refining & Marketing Co., Ltd.	Shell Haven, England	Comprehensive Refining	40,000 bbls.	.....	Under Constr.	Mid 1953	.....	.....	.....
Shell Refining & Marketing Co., Ltd.	Hamburg-Harburg, Germany	Refinery	8,950 bbls.	.....	Under Constr.	Late 1949	.....	.....	.....
Societe Generale des Huiles de Petrole	L'Avera, France	LPG Units	25,000 bbls.	.....	Under Constr.	Mid 1950	Kellogg	Kellogg	Staff
Societe Generale	Dunkirk, France	Crude Reform.	33,000 bbls.	.....	Under Constr.	Mid 1951	Lummus, Kellogg	Lummus, Kellogg	Lummus, Kellogg
Societe Generale	Dunkirk, France	Furf. Ref. Sol. Dewax., Wax Fractn.	2,400 bbls.	.....	Designing	Mid 1951	Texaco	Lummus	Lummus
Societe Industrial Belgique de Petrole	Antwerp, Belgium	Crude, Cracking Reforming	30,000 bbls.	.....	Designing	Mid 1951	.....	.....	.....
Societe per Azioni Raffineria Padana Olii Minerali	San Martino di Trecate, Italy	Refinery	13,000 bbls.	.....	Proposed	.....	.....	.....	.....
Socony-Vacuum Francaise	Notre Dame de Gravenchon	MEK Unit	1,000 bbls.	.....	Design	Mid 1950	Texaco	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Propane Deasphalting	1,100 bbls.	.....	Design	Mid 1950	Juik	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Grease and Compounding	.....	.....	Under Constr.	Mid 1950	.....	Staff	Staff
Standard Francaise des Petroles	Port Jerome, France	Dewaxing Plant	1,000 bbls.	.....	Planned	.....	.....	.....	.....
Standard Francaise des Petroles	Port Jerome, France	Deasphalting Plant	2,000 bbls.	.....	Planned	.....	.....	.....	.....
Standard Oil Co., N.J.	Belgium	Dist. Crack.	33,000 bbls.	.....	Planned	Early 1952	.....	.....	.....
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4—8 million	Plans approved	.....	.....	.....	.....
Union Petrol Refinery, Ltd.	Johannesburg, Union of South Africa	New Refinery	.....	$20 million	Projected	.....	.....	.....	.....
Near East									
Anglo-Iranian Oil	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian Oil	Abadan, Iran	Cat. Cracker	30,000 bbls.	.....	Under Constr.	1951	.....	Foster Wheeler	Foster Wheeler
Anglo-Iranian Oil	Abadan, Iran	Solvent Dewax.	400 bbls.	.....	Under Constr.	.....	Texaco	Badger	Badger
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4.8 million	Under Constr.	Summer 1950	.....	Staff and Fluor	Staff and Fluor
Arabian American	Ras Tanura, S.A.	Ref. Adds.	.....	.....	Under Constr.	1949	.....	Bechtel	Bechtel
Arabian American	Ras Tanura, Saudi Arabia	Asphalt Plant	300 bbls.	$1,250	Plans Approved	1950	.....	Staff, Bechtel	Staff
Bahrein Pet. Co., Ltd.	Bahrein Island	Expansion Program	.....	$8.3 million	Under Constr.	4th Qtr., 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
Bahrein Pet. Co., Ltd.	Bahrein Island	Crd. Still Utd.	55,000 bbls.	$9.1 million	Postponed	Aug., 1950	.....	Lummus, Bechtel	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	Late, 1951	.....	Badger	Badger
Consolidated Ref., Ltd.	Haifa, Palestine	Cen. Facilities	.....	.....	Under Design	.....	.....	Badger	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
Far East									
Bataafsche Pet. Mij. (Shell)	Balikpapan, Borneo, East Indies	Expansion	42,000 bbls.	.....	Under Constr.	Mid 1952	.....	.....	.....
Bataafsche Pet. Mij.	Pladjoe, Sumatra	Rehab. to Comprehensive Refg	70,000 bbls.	.....	Under Constr.	Mid 1951	.....	.....	.....
Burmah Oil Co., Ltd.	Syriam, Burma	Furf., Sol. Dewax., Wax Mfg.	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
Oceanic									
Australian Shell Oil Co.	Clyde, New S. W., Australia	Luboil Refining	250 bbls.	.....	Under Constr.	.....	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	New Refinery	.....	$4.8 million	Under Constr.	Late 1951	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Bitumen and Luboil Plant	.....	.....	Projected	.....	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Asphalt, Lube Solvent Extraction Plants	.....	.....	.....	.....	.....	.....	.....

* First appearance in tabulation. † Added capacity.

NOTE: Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Blaw-Knox—Blaw-Knox Construction Co. Bowden—W. H. Bowden. Braun—C. F. Braun Co. Brown Eng.—Brown Engineering Co. Brown & Root—Brown & Root Construction Co. Cat. Constr—Catalytic Construction Co. Chemico—Chemical Construction Co. C.B.&I.—Chicago Bridge & Iron Works Co. Clarke—Clarke Construction Co. Constr. Service—Construction Service Co. Delta—Delta Engineering Corp. Dresser—Dresser Engineering Corp. E.&A.–Ebrhart & Arthur, Inc. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Foster Wheeler—Foster Wheeler Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Girdler—The Girdler Corp. Graff—Graff Engineering Co. Hammond—Hammond Iron Works Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H.W.P.—Head Wrightson Processes, Ltd. Hydro Res.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J. & L. Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch—Koch Engineering Co. Koppers—Koppers Co., Inc. Knowles—Morris Knowles & Co. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. Mathews—Mathews Conveyor Co. McKee—Arthur G. McKee Co. Max Miller—Max B. Miller & Co. Montgomery—J. M. Montgomery & Co. Parsons—The Ralph M. Parsons Co. Petreo—(Division) Phillips Petroleum Co. Pet. Eng.—Petroleum Engineering, Inc. Petreo—Petroleum Rectifying Co. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Process Constr.—Process Construction Co. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. Rust Eng.—Rust Engineering Co. Rust Pro.—Rust Process Design Co. Schneider—Schneider & Cie. . Snare—Frederick Snare Corp. Sollitt—Summer S. Sollitt Co. S.O.D.—Standard Oil Development Co. State Eng.—State Engineering Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Stone & Webster—Stone & Webster Construction Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U.O.P.—Univeral Oil Products Co. Utah—Utah Construction Co. Waleo—Waleo Engineering. Wehlefd—Wehlefd Construction Co. Equally owned California Texas Corp. and Socony-Vacuum Oil Co., Inc.

DUPONT TETRAETHYL LEAD COMPOUNDS

Du Pont

Field Laboratories . . . At Work to Help the Refiner

Five Du Pont Field Laboratories, located in the major refining centers, are providing many diversified services to help the refiner in the solution of specific problems. These laboratories are completely equipped and staffed with experienced personnel. They perform the many tests essential to the efficient and safe use of TEL compounds and other additives; in addition, the scope of their work covers a far wider range of activities such as advice and aid on laboratory, as well as plant problems connected with the use of additives. As a result, many refiners are finding that their helpful assistance and recommendations are enabling them to produce better fuels . . . more economically. If you haven't already done so, avail yourself of this useful service.

DU PONT

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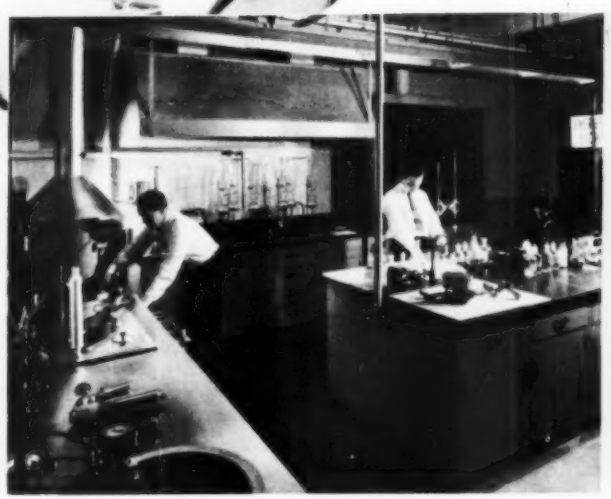
Better Things for Better Living
. . . *Through Chemistry*

A complete line of

Sulfur determination is only one of many standard A.S.T.M. tests which the District Laboratories are equipped to run.



The inspection section of each field laboratory has the latest and most modern equipment for helping on problems dealing with the use of Du Pont TEL compounds and other additives.

gasoline additives...

PLUS...

A Complete Laboratory Service

Help You Meet Your Fuel Requirements . . .

Efficiently . . . Economically

Each Du Pont District Laboratory is a complete unit with full facilities for determining lead susceptibility and for making knock tests on motor gasoline as well as chemical analyses. This, and the fact that Du Pont supplies a complete line of gasoline additives including tetraethyl lead compounds, enables them to make recommendations covering the entire additive requirements of fuel.

Laboratory records show numerous case histories that demonstrate the type of help Du Pont District Laboratories are providing. For example; several refiners were faced with meeting rigid octane specifications. The Du Pont laboratory serving that area ran lead susceptibility tests on many combinations of blending stocks including iso-pentane blends. From the information developed through these tests, the refiners were enabled to meet competitive octane specifications. In another case a suggested change in processing sequence and the addition of antioxidant at an earlier stage led to improved gasoline storage stability.

Instance after instance proves that the helpful cooperation of Du Pont District Laboratories is aiding refiners in the solution of many problems related to additive usage and gasoline refining.

The knock testing section renders many helpful services in connection with determining lead susceptibility of stocks and checking octane number of refiner's blends.

DU PONT

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BETTER THINGS FOR BETTER LIVING...*Through Chemistry*

Du Pont Laboratories Provide Nationwide Check

Of Gasoline Octane Ratings and TEL Content

Tetraethyl lead analyses are run by each District Laboratory as part of their service to refiners in the area.

As a marketing information service to refiners, Du Pont District Laboratories periodically obtain and check filling-station samples of gasolines sold in their area. These fuels, both premium and regular, are tested in the laboratory to determine the octane number, both motor and research, as well as the amount of TEL per gallon.

These reports on individual gasolines are coded and listed so that the interested refiner can check his fuels not only against averages but against individual fuels. These valuable reports are made every three months. This is another example of the helpful services provided by Du Pont Research Laboratories . . . to help the refiner meet specific marketing requirements.

DU PONT

PETROLEUM CHEMICALS DIVISION
MOTOR GASOLINE SURVEY

CITY	CODE NO.	PREMIUM			REGULAR			DATE SAMPLED
		OCTANE NO.		TEL CC/GAL.	OCTANE NO.		TEL CC/GAL.	
		MOTOR	RES.		MOTOR	RES.		
New York, N. Y. (Metropolitan Area)	34	80.9	88.4	2.40	79.4	86.6	2.65	9-26
	47	81.7	89.8	2.53	80.5	85.2	2.64	"
	50	80.8	91.7	0.96	76.0	83.6	0.29	"
	56	80.9	88.2	1.36	80.1	85.0	1.29	"
	61	83.2	88.7	1.79	76.3	83.0	1.34	"
	64	81.3	89.2	1.81	79.0	83.1	1.70	"
	71	82.1	88.7	1.36	80.4	83.4	1.42	"
	72				76.6	84.4	Nil	"
Average		81.6	89.2	1.74	78.5	84.3	1.42	
Philadelphia, Pa.	34	77.7	86.0	1.09	76.0	82.5	1.12	9-27
	37	80.0	89.7	1.22	75.9	83.3	0.70	9-23

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

Tetraethyl Lead Compounds
(Motor Mix—Aviation Mix)
Antioxidants
Metal Deactivator—Dyes

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E. I. DU PONT DE NEMOURS & COMPANY (INC.)
PETROLEUM CHEMICALS DIVISION
Wilmington 98, Delaware

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PETROLEUM
REFINER
NOVEMBER, 1949

Aviation gasoline demands are especially high with modern long-range and high-speed bombing tactics, and with jet-engined fighting crafts—but whatever the operation even the small planes don't fly without gasoline. If they are to excel in performance, the gasoline must be of superior quality. This World War II seaplane is being refueled by tank truck at water's edge of a South Pacific island. The 100 octane gasoline used in this war was produced through the joint efforts of some 160 odd U. S. refiners.

Liquid Fuel Supplies And National Security

WALTER G. WHITMAN
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AN ADEQUATE supply of liquid fuels is imperative to national defense. During the last war petroleum represented 60 percent of the tonnage shipped to the war theatres, and much larger volumes were used at home for basic transportation and other essentials. Another major war would almost surely develop greater requirements once it was well under way.

This discussion attempts to analyze the technological problem of liquid-fuel supplies in a future national emergency, and to suggest means for reasonably assuring that the needs are met.

The time scale which is implied when referring to a "future" situation needs definition. In his "Major Sources of Energy," delivered last year before this division, Eugene Ayres looks centuries ahead. By contrast, "Report on the Long-Term Availability of Petroleum," which is referred to later, restricts itself to the next 10 years. In the present discussion anything within the next 10 years is considered "short-term"; "long-term" implies a period from 10 to perhaps 40 years.

I.) THE RESPONSIBILITY FOR SECURITY

If we were certain of world peace, the United States could fairly rely on private enterprise alone to secure its liquid-fuel supplies for the indefinite future. Depletion of domestic crude reserves would have the effect of further encouraging domestic and foreign exploration and the development and construction of synthetic-fuel plants. The timing of these changes in source of supply need not be predicted far in advance, because the shifts would not be disruptingly rapid.

In contrast, the possibility of a major war introduces the complications and compulsions of national security. Timing becomes a dominant factor in assuring a state of readiness for emergency.

In the past few generations this country has enjoyed the privilege of living through the periods between its wars in a peacetime atmosphere and economy. Major wars started elsewhere, and we had time to readjust and to arm before engaging as participants. Our military forces were small, because we saw no need to pay high insurance premiums against the possibility of sudden enemy attack.

The current expenditure of some $15 billion annually for a military establishment exemplifies a changed attitude. No longer do we count on having years to arm before coming to grips with an aggressor. The country feels that we must be ready, and it is willing to support policies and expenditures which are definitely uneconomic in peacetime save as insurance premiums against future war.

MUCH OF THE current discussion in oil—and other—circles these days deals with the future liquid fuels supply, particularly in case of an emergency. The author of this article, which was presented to a group session on "Fuels of the Future" under auspices of the Division of Refining during the meeting in Chicago early this month of the American Petroleum Institute, takes up the essential factors bearing on the problem and offers some interesting conclusions. Government projects as to liquid fuels, he says, need not extend beyond basic research, detailed planning for quick stockpiling and production increases when the emergency comes. Continuing close liaison between government and the oil industry in defense planning is termed "essential."

If national security demands that actions be taken which are not sound investments for private enterprise, the people as a whole, through their government, must accept the responsibility and pay the cost. No company or group of companies can, or should, be expected to assume such responsibility and to bear such costs voluntarily in our competitive system.

However, the fact that government must finance full expense of a military establishment, which is useful only to prevent or to prosecute war, by no means implies that an active industry which is devoted to supplying liquid fuels in peacetime may not be able to assume the burden of wartime supply without prior government participation in its operations. The principle that government has the responsibility for national security is inescapable, but the discharge of this responsibility may or may not require government expenditures in any given activity during peacetime.

II.) WARTIME REQUIREMENTS OF LIQUID FUELS

No one can foretell the number of barrels per day of liquid fuels which would be called for to meet basic requirements in a future war. However, the history of domestic consumption through the past 30 years discloses that the last war period is not distinguished by any greater percentage increase in total demand than has occurred during healthy peacetime years. Thus over the 11-year period of 1919 through 1929 total domestic consumption grew rather steadily from 1.03 to 2.58 million barrels per day, approximating an increase of 9.6 percent per year before the depression checked demand; over the 4 years 1938 through 1941 it rose from 3.12 to 4.07 million barrels per day, an increase of 9.2 percent per year; and over the 4 war years of 1942-1945 it rose from 3.97 to 4.84 million barrels, at 6.8 percent per year. The postwar growth through the next 3 years (to 5.76 million barrels per day in 1948) corresponds to 6.0 percent per year. The same general conclusion is reached by examining the figures on world production of crude oil.

Of course, the war period brought rationing of liquid fuels, just as war naturally requires rationing of most basic commodities. But few would contend that the war effort was appreciably impaired by oil rationing, and the record is clear that military needs were satisfied.

Another war may, if long continued, bring unsatisfiable requests for tremendous volumes of jet fuels to power combat planes and missiles. But civilian rationing can be far more rigorous than it was last time if it is well-planned in advance. And it is sobering to realize that Germany and its allies prosecuted an aggressive war for more than 5 years, with a peak production of less than 400,000 barrels of liquid fuels per day.

Considering the unknowns of time, place, the enemy, the weapons, it is reasonable to assume that the requirements' goal in another war will be a production which increases above the prewar rate by the same percentage as would apply in years of peacetime prosperity. This concept may have to be modified with time. But, frankly, war plans based on any great excess over this total volume would appear to demand such excessive national expenditures, continuing for indefinite periods while a potential enemy may bide his time, as to debilitate seriously our economy. In a recent article entitled "A Program for World Peace" (*OIL Newsmagazine*, July, 1949) James H. Doolittle discusses preparedness, and warns against its extremes with the statement: "We could easily destroy ourselves through the dissipation of our resources in being always ready."

The discussion of requirements has so far dealt only with total volumes. In addition, there will be insistent demands for special war products, e.g., aviation gasoline, toluene, and synthetic rubber in the last war, which will chiefly affect the refineries but which may have repercussions on transportation, and even on production. It must be realized that some specialty programs may be poorly managed at the start, as was the case with aviation gasoline and rubber until some months after Pearl Harbor. Such mistakes will result in subsequent "crash" programs, conflicting for high priority with technological developments like the atomic bomb which are not predictable prewar. Coordinated industry-military planning will minimize these "avoidable" crises and their drag on war production.

It is pertinent here to differentiate between the use of the word "requirements" in an economy of peace as against one of war. In war, "requirement" means the absolute need for a product because of its contribution to the integrated war effort. A scale of essentiality must be established by over-all planning. On this scale, which will, of course, change with conditions, a 10-percent increase in diesel fuel for domestic railroads might at times be more essential than a 10-percent increase in jet fuel for planes, and priorities for some new secret project might override both.

When the word "requirement" is applied to a peacetime situation, it has a quite different meaning—representing the total amount which people are willing to buy at existing prices. Some of the total represents a real need which cannot be satisfied in other ways, whereas some of it is merely the amount which can be sold in competition with other materials of equivalent usefulness, e.g., residual fuel competing with coal in large power stations on a straight heating-value basis.

Summary on Requirements

The absolute requirements of liquid fuels for a war in the unknown future, including essential civilian and indirect military, are indeterminable. However, the constantly increasing importance of liquid fuels to our daily living and the expanding plans of the military for power plants which consume ever greater amounts of fuel, particularly in the air, indicate that requirements would become much greater than in the last war. The assumption that war requirements will bring an increase over the prewar years which will approximate the percentage increases which characterize prosperous peacetime periods is supported by the record of the last war and, in my opinion, is the most realistic approach at present to the problem of total liquid-fuel requirements. Meeting such needs within the inevitable wartime restrictions of manpower and materials may indeed prove a tremendous challenge.

III.) SUPPLIES

The problem of assuring supplies on a scale which will meet war requirements has enlisted much thinking by industry and government, and has elicited such diverse suggestions as stockpiling products, importing crude, creating government crude-oil reserves, constructing synthetic-fuel plants, and prewar rationing. It is proposed to analyze various techniques which might be considered, viewing them in their relationship to national security. The problems are much too complex for any one individual adequately to comprehend and judge. Chief qualifications for such a study are experience in petroleum refining, service with the War Production Board in the last war, and a relatively objective viewpoint.

1) General Considerations

The significance of timing stands out in any broad consideration of national security. If we knew when and where we would be attacked, many questions would be readily resolved. But a program which concentrated on preparation for a war within the next 4 years might well embody policies and actions which would prejudice our security if the war were to come 25 years from now. For example, to what extent should we conserve our crude resources by reducing wasteful prac-

tices in consumption as well as in production, by discouraging marginal uses, or by importing large volumes of foreign crude, in order to have a stronger resource position 25 years from now?

Timing is also a dominant factor in planning specific measures for meeting war requirements. There may be large fields of recoverable oil under area "X" which would be useful in war; but, if the region has not been well prospected before war breaks out, the chances that they will contribute in the emergency are almost negligible. On the other hand, a field which is only partly developed at the beginning of a war may be susceptible to rapid development and important production within the next year or two.

The oil industry is alert and responsive to short-term trends. Ever-changing forecasts of demand and supply for the near future must guide the day-to-day decisions of the many units in a highly competitive business. It is significant that the industry is always verging on a shortage or an oversupply of products, as is well illustrated in the history of the past two years. Just as the individual is stimulated to greater accomplishment when he lives in a changeable and unpredictable climate, so the oil industry's vigor and flexibility are due in considerable measure to its restless economic climate. But the tenseness which characterizes the industry's daily operations tends to relegate to the background long-term considerations.

B) Characteristics of Crude Production

When one considers raw-material supplies for liquid fuels in an emergency within the next 30 years, it is apparent that crude oil will be the mainstay, if not the total source. The question of crude supply is, therefore, of paramount significance.

Oil production has two major tasks, viz.: finding oil and recovering it. As refiners, it is well to realize that more than half the investment and more than half the operating costs of the oil business are in production.

The API Committee on Petroleum Reserves estimates our proved domestic reserves at the end of 1948 as 26.8 billion barrels of total liquid hydrocarbons (23.3 billion barrels of crude and 3.5 billion of natural-gas liquids). It has been customary in the industry to divide the year-end reserve figures by the crude production for that year to obtain a figure which is known as "years' supply," or number of years of proved reserves. This ratio has varied between a maximum of 17.7 in 1919 and a minimum of 10.4 in 1923. For 1948 it shows 12.2 years.

Combat vehicles such as tanks and mobile gun carriages require great volumes of gasoline, but constitute only a part of the fuel demands of an army. Equally vital are the fuel requirements of motor transport and construction machines such as this bulldozer with which an engineer group works at clearing a blasted railroad embankment.

There has been much misunderstanding and misuse of the committee's figures. Its report explains that the estimates "refer solely to proved or blocked-out reserves—recoverable under existing economic and operating conditions." For example, the reserves credited to a new field brought in by a wildcat well during 1948 would usually be calculated only over a small area which could be regarded as proved. Development of the field in subsequent years might "prove" many times the amount of oil which was credited to the field when it was first discovered, and the addition would be included in later years as "extensions." Similarly, an increase in probable recovery from a field because of the installation of secondary-recovery facilities, or because the price of crude went up and thus postponed the abandonment of stripper wells, would be reflected at the time by adding reserves under the heading of "revisions."

It seems reassuring for future supplies that the proved-reserve estimates have increased by 2.8 billion barrels in the past 2 years, despite high production rates. Yet the optimism generated by these figures may be unjustified; i.e., 89 percent of the new reserves were derived from extensions to known fields and revisions of previous estimates. As is always the case, the true extent of the new discoveries is as yet unknown, and it will take perhaps another five years before development of the new fields will be sufficient to permit a reasonable appraisal.

During the war the PAW tabulated new discoveries in a different manner by crediting revisions and extensions back to the year when the field was discovered. This method, based on information available in 1948 and applied to the years 1935 through 1942 (*Petroleum Data Book*—2nd edition) credits those years with about 3.6 times the volume of new discoveries which the API committee ascribed to them just after the year of discovery. If this multiplying factor of 3.6 were applied to the API committee's estimate of new discoveries in 1947 and 1948 (966 million barrels total liquid hydrocarbons), it would indicate new findings of only about 3.5 billion barrels, as against production during those 2 years of 4.2 billion barrels.

Probably no great reliance can be placed on this method of extrapolating the results of recent discoveries of new fields beyond the conservative "proved-reserve" figures of the API committee. You cannot tell for some years how much oil has been found when a wildcat brings in a new field.

The cost of finding new oil is steadily increasing. Exploratory costs, which totaled about a quarter of a billion dollars annually in the prewar period, are now running well in excess of a billion (Struth, "Petroleum Engineer," January, 1949). Oil is progressively harder to find, and requires more scientific effort and deeper drilling. Drilling costs, which make up about half of the total, increase about with the square of the depth; thus, a 10,000-foot well averages about 4 times the cost of a 5,000-foot well. Annual geophysical costs in the United

States are estimated as 125 million dollars (Eckhardt, "Oil and Gas Journal," March 17, 1949); geological expenditures may be almost as high; and land and lease expenses are estimated at around two to three hundred million. Incidentally, about 10 percent of the area of the United States is under lease by oil interests.

Producing Capacity

Proved reserves are the source of production, but they do not tell how fast the oil can be produced. Rate of production is a complex problem which involves field and well characteristics, economics, state regulatory commissions, and human nature.

The East Texas field, for example, has been producing for many years under close control to hold bottomhole pressure at not less than 1000 psi. and thereby avoid gas evolution in the formation. It produces almost 2 barrels of salt water per barrel of oil, 90 percent of the water being pumped back and helping to maintain the water drive. Under these conditions, East Texas produces around 300,000 barrels of oil per day, or a little less than 5 percent anually on its estimated remaining reserves of 2½ billion barrels. Many fields can be operated efficiently at a higher rate of exhaustion; others are operated at high rates regardless of efficiency. The average rate for the country as a whole is about 8 percent per year.

One of the challenging problems of oil production is to determine the proper rate for withdrawing oil from a field, with due regard to economics. Reservoir engineers have developed a concept known as "maximum efficient rate" (MER) (Edgar Kraus, API 28th annual meeting, November 11, 1947) which takes into consideration the effect of rate on ultimate recovery and economic return from the field. A proper MER establishes a ceiling for production rates which should not be exceeded. Actual rates may, of course, be less than this ceiling to conform with market requirements.

It should be emphasized that the "maximum efficient rate" for a pool is not some fixed characteristic of the pool alone, but is affected by many variables which may change with time; e.g., well spacing, unitization, operating costs, income from the field, secondary-recovery techniques like pressure maintenance and water injection, and other engineering adjuncts which may become justifiable under changed conditions. The MER for some pools is easily determined and, therefore, readily agreed upon by different reservoir engineers; but many pool analyses develop sharp differences of expert opinion. When one speaks, therefore, of the total "maximum efficient rate" of all the producing fields in the United States, it must be recognized that the summation includes many pools which are not properly rated, or which are not rated at all. With this qualification, it seems probable that the "total" MER of U. S. fields was equivalent to the crude production late in 1948, or about 5.6 million barrels per day of crude (exclusive of natural-gas liquids) at that time. Today it should be close to 6 million barrels because of additional well completions, which would more than balance declines in the intervening period.

Constant drilling of new wells is essential. On the average, we should find enough new reserves each year to balance the year's production and also to provide the base reserve for any increase in production next year which may be necessary to meet expanding demand. Thus, if 5 percent greater production is desired next year, the findings per barrel of oil consumed should be 1 barrel of replacement oil plus enough more oil reserves to permit 0.05 barrel more production. Assuming the country average of 8 percent annual production on reserves (which perhaps exceeds MER), the extra 0.05 barrel to be produced will require finding about 0.6 barrel of new reserves. Therefore, the total desired finding would be 1.6 barrels per barrel produced.

Another way of visualizing the need for new findings is to regard it from the standpoint of production rates. If no new wells were drilled, and if all present fields operated at their MER's, the MER of the country as a whole would decline about 8 percent anually. Again assuming a 5-percent increase in desired production, the wells now in existence would produce only 88 percent of the desired amount next year; i.e., 12 percent should come from new wells. Of course, if demand were not up to the MER of the country, the decline would be less.

PAW made some interesting estimates on this point, and concluded that the efficient productive capacity of the country would have dropped almost 30 percent in the 44 war months to V-J day if there had been no drilling after Pearl Harbor. The calculated percentage drop would presumably have been greater except that total demand was below efficient productive capacity in all but the last year of the war and, hence, production was not pushed to capacity in the earlier years.

PAW made another estimate which assumed that there was no exploratory drilling after Pearl Harbor, but which allowed for the actual drilling of development wells in producing fields. On this assumption, the calculated loss of efficient productive capacity over the same war years was 16 percent.

The intensity of the search for oil is closely related to the anticipated profits from its discovery. Strong demand and high prices for crude greatly stimulated all phases of crude finding in 1947 and 1948, when the number of seismic crews increased to 500 and the number of exploratory wells drilled jumped to a record 2-year average of 11,600 per year, which is about double the average drilling rate for the 5 years before the war.

The process of finding and developing oil pools involves a time lag which is comparable with the time needed to develop a new refining process from small-scale laboratory research to successful commercial operation. The time required for drilling wildcat wells is short in comparison with the three to five years of preliminary exploration and analysis of data which went into selecting the site. However, so many wildcats prove to be dry that a time allowance of one year between the decision to drill and the finding of oil is a fair approximation.

Subsequent development of a newly discovered field by drilling proceeds at a rate which is greatly conditioned by the demand for its oil. On an average, it may take three to five years to develop a field to reasonably full capacity, but in an emergency this could probably be reduced to a year if the drilling equipment, supplies, and manpower were available.

Summarizing, it takes on an average some 7 to 10 years to obtain reasonably full development of a new field from the time when exploratory studies of the area are initiated.

Reserve Producing Capacity

Reserve capacity to produce oil beyond immediate demand was normal in this country before the war. During 1941 we had about 900,000 barrels per day of surplus capacity within efficient producing rates; in fact, the production capacity of the country was not really challenged until the middle of 1944, despite subnormal drilling in 1942 and 1943. Transportation, rather than producing or refining, limited output, and military consumption developed at a relatively slow pace. The increase in demand likely would come more quickly in another war, and reserve capacity should be exploited at once to fill product stockpiles.

From 1944 until 1949 the reserve capacity has been negligible, chiefly because exploration and field development did not keep up with demand during the war and because steel continued to be short, postwar.

Today we apparently have a U. S. capacity at "maximum efficient rates" of around 6 million barrels per day (not including another 450,000 barrels daily of natural-gas liquids). This means a reserve producing capacity of almost a million barrels a day. Total capacity is constantly changing—tending to decrease as present wells decline and stripper wells are abandoned, and to increase as new wells are drilled in existing fields, the limits of present fields are extended, new fields are discovered, and improved operating techniques like pressure maintenance and water injection offset declines. It is a startling fact that more than 40 percent of our total producing capacity today is from wells which have been drilled since the end of the war.

The true measure of reserve producing capacity is not merely the added production which could be obtained by opening up existing wells. Behind this immediate reserve are the fields which could be developed rapidly by emergency drilling. And, to a lesser extent, the existence of a large store of exploratory information which indicates likely prospects for wildcatting contributes to the reserve capacity to produce in time of need. Producing companies normally have enough promising locations for exploratory drilling lined up to keep their drilling rigs busy for a year or more.

This picture indicates a considerable flexibility in productive capacity, depending upon the demand for crude oil. Over a period which is short in terms of national security—5 or 10 years—producing capacity is closely related to the amount of exploratory and development activity of the years just preceding. If the prospects of profits are good, such activity will be high. On the other hand, if the preliminary phases of the search for oil—basic research on better methods for detecting the existence of pools, scientific prospecting, and wildcatting—were curtailed by conditions which discouraged exploratory and development enterprise, capacity might hold up for a couple of years, but would then begin to drop.

C) Stockpiles

Stockpiles of basic essentials are a tremendous asset in war. Stockpiling need not be restricted to imported materials. With domestically produced materials it often can be instituted effectively as soon as an emergency is evident by a process of strict rationing and the elimination of less essential use, at the same time calling for maximum production and stockpiling the excess. Two examples:

Soon after Pearl Harbor it became evident that large amounts of benzene would be required to make styrene for the synthetic-rubber program. Although the need was at least a year ahead, strict allocation of benzene was instituted at once, and its use in motor fuel was prohibited. Almost two-thirds of the country's benzene production thereby became available for stockpiling, and a healthy reserve for the rubber program was established before styrene production got under way. Subsequently it developed that the aviation-gasoline program required benzene to make the additive, cumene. By a combination of maximizing production and drawing on the stockpile, this need was also met in full.

Industrial alcohol affords a parallel illustration. The production of butadiene for synthetic rubber was originally planned on the basis that the petroleum industry would provide most of the butadiene but that about a third would come from plants which used alcohol as a raw material. The prospective requirement for alcohol far exceeded the capacity of the regular industrial-alcohol plants; therefore alcohol was put under allocation, and all the whiskey distilleries were converted to industrial-alcohol production. When the alcohol-butadiene plants swung into operation in 1943, the alcohol stockpile was sufficient for eight months' feed for all three projected plants at rated capacity. This proved to be most fortunate; for it turned out that alcohol-butadiene had to carry the lion's share of the butadiene program, producing more than two-thirds of the amount used in synthetic rubber through the crucial period of 1943 and 1944. Incidentally, these alcohol-butadiene plants actually developed almost twice their rated capacities, with a correspondingly increased appetite for alcohol. Without the advance stockpiling to supplement maximum current production the needs for the rubber program would not have been met.

The same technique of rigorous rationing or allocation when the emergency is evident and the creation of a stockpile before essential war consumption has developed should be applicable to petroleum. To do it, there are two essentials:

1. The allocation or rationing program to eliminate less essential use should be instituted promptly when the emergency becomes evident.
2. Tankage must be available to receive the excess of production over the allocated supply and thereby build the stockpile.

These two steps call for thorough and realistic advance planning. It would be futile to restrict civilian usage if this merely meant that crude production and refinery runs had to be reduced because all tanks were full. The object is to build as big a stockpile as possible against future demands, not to be rough on the civilian.

As a rough prognostication, such a stockpile might receive at least 20 percent of the country's production for an equivalent of 10 months. At current rates this would create a stockpile of 360 million barrels in the first year of the emergency. (Note that this figure is more than twice as large as the present difference of 150 to 160 million barrels between "low" stock and "high" stock inventories in industry tankage.) A stockpile of this magnitude can play a vital role in a war program, supplementing inadequate production later on when demands become heavy while production capacity is being enlarged.

Again referring to the timing factor which so frequently enters security considerations: It would be essential to have a part of the necessary tankage ready before the emergency is evident; 150 million barrels of empty tankage, costing about $200 million and located strategically to receive refinery products by short pipe line, might be adequate in advance. It should be understood that this is not a prewar stockpile of military products, but is empty tankage, ready to receive the "first fruits of rationing." Additional tankage could be erected in time if its location and construction were planned beforehand.

The question of what should be stockpiled does not seem to be too important, except that it should be products which will be essential to the war program. The two least desirable stockpile items are crude oil and residual fuel, i.e.: crude, because its stockpiling does not help to keep refineries running at maximum capacity from the start; and residual fuel, because its yield can be increased at any time without strain on refineries. The most desirable products would be those which are going to require the most effort to produce in the desired volumes.

In contrast to this program of stockpiling when the emergency starts, oil products might be stockpiled during peacetime years in anticipation of an emergency. One scheme which has had some consideration is to refine and store the products from an extra half-million barrels of crude a day for perhaps five years. In such a program the stored products should, of course, be kept reasonably fresh by withdrawals to market and replacement on the principle of first-in-first-out. The proposal has the merit of creating re-

serve capacity in refining as well as in crude production while the product stockpile is being accumulated. It would, however, represent a tremendous expense for government to acquire and store 900 million barrels of products at a probable cost, with tankage, of more than 5 billion dollars, and presumably to retain this stockpile indefinitely pending a war emergency. Stockpiling of such volumes of oil aboveground in peacetime appears to be an unnecessarily extreme solution compared to other possibilities.

On the other hand, some prewar stockpiling of especially urgent war products which require considerable processing would be advantageous both in creating the reserve stock and in keeping activated a core of the necessary refining facilities. Toluene and aviation alkylate are products of this type which might well be stocked in moderation during peacetime, perhaps to the extent of two or three months of anticipated demand. For toluene, this might mean a million barrels; and, for alkylate, 20 million barrels.

D) Imports

In recent years the proved reserves of crude outside the U. S. have been greatly increased, largely as a result of American enterprise. South American proved reserves, chiefly in Venezuela, are some 10 billion barrels. The Middle East has proved perhaps 33 billion, or more than the U. S. total.

Canada which is now credited with only ½ billion barrels, is expected to prove anywhere from 5 billion up to 20 billion in the next 15 years. However, in a war emergency, Canada and the U. S. should be treated as a unit because of geographic proximity and the similarity of interests and political philosophy, and Canadian oil can, therefore, be classed with domestic oil in security planning.

The import question is today most controversial, and comments will be restricted to its effects on national security.

Present plans for Middle East oil development are limited to meeting requirements of the Eastern Hemisphere, notably our European allies of the North Atlantic Pact. It is displacing Venezuelan oil from Europe on a straight economic basis because of lower costs at the port of loading, despite a transportation disadvantage of about 50 cents per barrel to Atlantic ports in Europe. Therefore, Venezuelan oil which has been going to Europe, to the extent of almost ½ million barrels per day, should be readily available to us, above the 400,000 barrels or 500,000 barrels per day which we have been receiving. Such oil would logically be refined near the big consuming areas of the East Coast, increasing this district's proportion of the country's refining capacity.

There are two security arguments against importing as much as a million barrels per day from South America, both bearing on the short-range aspects of security:

1) A major war might well stop the flow of Middle East crude, and our European allies would then need an equivalent amount from South America — thereby diverting practically all our imports of South American crude to Europe, and requiring an equivalent production increase in North American crude. However, if we do not accept South American imports in peacetime, it is quite possible that they would not be available for diversion to Europe in a war emergency. (It is, of course, conceivable that enemy submarine action might prevent any Venezuelan crude shipments either to Europe or to North America, but in such a contingency the sea lanes would also be closed to extensive overseas military operations, and the attendant large military consumption would not exist.)*
2) Imports will reduce the demand for domestic crude and, thus, reduce the incentive for exploratory activity in this country. This would adversely affect our productive capacity within a very few years, although it would leave us with greater domestic reserves for the more distant future.

The import issue points up a conflict between short-term and long-term security. Heavy imports today, although they would not prejudice security for the next year or two, might impair our domestic potentialities 5 or 10 years from now because of their withering effect on domestic exploration. On the other hand, the long-range interests of the country would be served by extensive imports of crude, both by fostering a healthier world economy in which there would be less danger of war and by conserving our native resources for the security of the following generation.

It is pertinent to note that imports of heavy crude which are processed primarily for industrial and utilities fuel would have less effect on domestic crude economics than if the imports were of light crude for refining. Nevertheless, from the security standpoint, the effect is rather similar in nature in that the coal-producing industry bears the shock of market contraction. Contrary to popular belief, coal production is no more expansible in a short time than is oil, if as much, and the loss of coal markets results in abandoning mines which can probably never be reopened in an emergency, as well as in the contraction of coal-transport facilities. For equivalent daily production (in heat units), a modern coal mine requires less initial expenditure but much more operating labor than does the average oil field.

E) Synthetic-Liquid Fuels

It seems fair to assume that there will be a heavy demand for liquid fuels for at least the next century or so; beyond that we need not be too concerned because, if science renders them obsolete, it will do so by providing something better. Liquid fuels are uniquely fitted to supply the energy for propulsion over the highways, the railroads, the seas, and in the air. For stationary energy units — such as homes, commercial units, industries, and power stations—they are merely another source of Btu's, usually more convenient than coal but less so than natural gas.

It also seems evident that some day the finding and development of enough crude to meet demand will become so expensive that the production of liquid fuels by synthesis will be equally, or more, attractive. How soon this will occur on a significant scale is speculative. It depends on four factors:

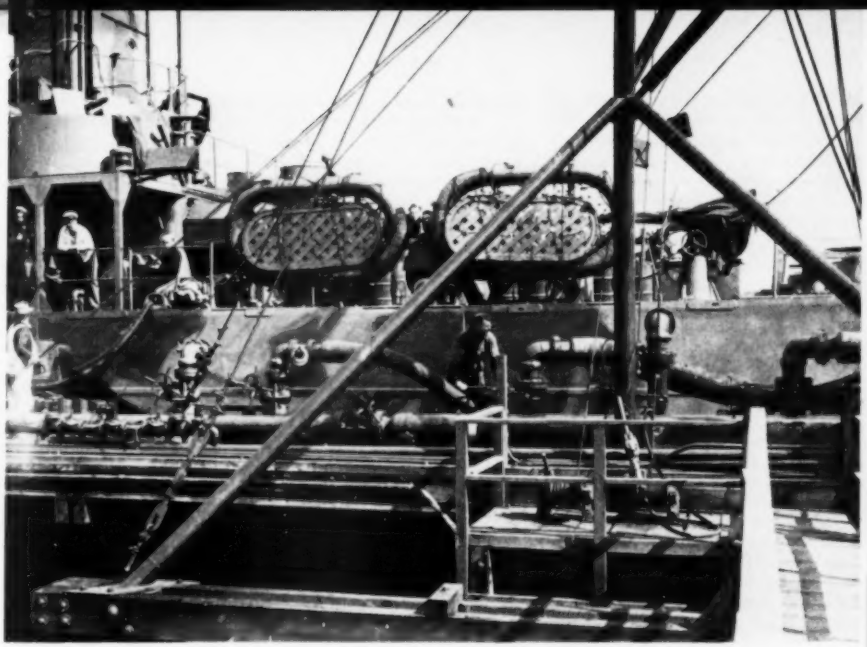
1) *The cost of producing new supplies of crude:* There is a considerable time lag in determining this cost because, as pointed out hereinbefore, we do not know how much crude has been found in a given year until many years later.
2) *The cost at which synthetics can be produced,* which is a function of technological development.
3) *Our willingness to import foreign crude.*
4) *The future demand for liquid fuels,* considering both the desire to use increasing amounts and the effect of their becoming more expensive.

Enough is known today to asure that liquid fuels can be produced from coals, from natural gas, from shale, and from other sources of carbon such as tar sands. Germany produced approximately 120,000 barrels per day, or 42 percent of the liquid-fuel supply available to her, by synthesis from coal during the last war. Alcohol from agricultural byproducts was used as motor fuel in some countries which were unable to get enough gasoline for essential needs during the war.

Synthesis From Natural Gas

The first commercial production of synthetics in the U. S. is expected shortly from the Hydrocol plant now under construction at Brownsville, Texas. Natural gas is combined with

*The logistics of transporting supplies to overseas war theatres are not treated here. However, it is pertinent to note that: 1) South American oil is strategically well located to supply both Atlantic and Pacific operations, and did so effectively in the last war; and, 2) the movement of Middle East crude in peacetime requires a large tanker fleet, which is a strong security asset.



An adequate supply of petroleum products is absolutely essential for present day military operations. Navy, army, and air forces base their efforts upon ships, transport and combat vehicles, and aircraft, respectively—and all these machines are powered by liquid fuels from petroleum. In this World War II scene, a tanker takes on a cargo, probably aviation gasoline, for transport to a combat zone.

oxygen extracted from the air to form carbon monoxide and hydrogen. The resulting "synthesis gas" is then catalytically converted to liquid fuel and byproduct chemicals in a modified Fischer-Tropsch process. About 7000 barrels of liquid fuels per day are expected from this plant. The realization from the byproduct chemicals will be a significant factor in the economics of the operation.

Synthetics from natural gas will probably not be an important contributor to our future liquid-fuel supply. Natural gas is a very superior fuel on its own when it can be brought to market economically. It has had very low value at the wells in the Southwest because of the long distance to densely populated areas, such as the East Coast, and the relatively few gas-transmission lines. Today there are several major pipe lines from Texas to the East Coast, and one to California; and others are building or planned. Texas gas can be delivered from the pipe line in New York at perhaps 30 cents per 1000 cubic feet, equivalent on a Btu basis to residual fuel at $1.30 per barrel, and to eastern bituminous coal at $7.50 per ton. Such a setup certainly encourages natural-gas pipe lines to supply the centralized quality-fuel markets in competition with distillate oil and coal for space heating, and to spill over into industrial and utility plants (displacing oil and coal) to the extent that the fluctuating demand for higher quality uses does not utilize the full capacity of the pipe line. Further, by displacing or enriching manufactured gas, natural gas reduces the use of oil in gas manufacture, a field in which oil has greatly encroached on coal. This is an interesting example of inter-fuel competition.

It appears that natural gas will in most instances have a higher value for direct use as a fuel than it will have as a raw material for making liquid fuels. Cases may be encountered where distance from market is so great that a large reserve of natural gas would preferably be converted to liquid for transportation to market; e.g., where tanker transport was readily practicable but a gas pipe line would be to expensive, or where local demand for oil in an area where there was plenty of gas but no oil would justify synthesis.*

Oil From Shale

Tremendous reserves of shale in the western states could be processed by destructive distillation to yield around 25 to 30 gallons per ton of a low-grade oil which could then be refined, probably by hydrogenation, to desired products such as diesel oil, and even gasoline. The Bureau of Mines reports excellent progress in developing large-tonnage mining methods at its station in Rifle, Colo. Several organizations are working to develop a suitable shale retort, with emphasis on low water requirements because the region is semi-arid. Present thinking favors preliminary cracking of the oil at the retort site to improve its viscosity and pour point so that it can be pumped to consuming areas like the West Coast for refining.

Estimates of the oil recoverable from shale reserves in western Colorado run up to 200 billion barrels, i.e., more than the probable amounts of recoverable crude oil in the U. S. The progress which is being made in developing mining, retorting, and refining methods has created considerable enthusiasm for shale oil as the first probable supplement to crude oil in the production of liquid fuels on a large scale.

Oil From Coals

Germany produced oil from coal, both before and during the last war, by hydrogenation and by the Fischer-Tropsch synthesis. As yet neither of these processes is economic in the U. S. because of the availability of petroleum. This is well illustrated by the fact that residual fuel oil, which would certainly be a better raw material than coal for producing gasoline by either hydrogenation or Fischer-Tropsch synthesis, competes with coal on a straight heating-value basis in large power stations on the East Coast and on the Great Lakes. Before coal becomes of interest as a raw material for oil, the refineries will have improved their processing of petroleum so as to produce higher yields of the more valuable distilled products and so as prac-

*Note that oil-transportation costs from a Gulf Coast field to a utility in New York Harbor usually run about 55 cents per barrel (gathering, pipe-line, terminals, tanker-and-barge) or 8.7 cents per million Btu; whereas the cost of transporting natural gas by pipe line to New York, at about 25 cents per 1000 cu. ft., is 24 cents per million Btu delivered. The difference is primarily investment cost, which is about five times as great for the gas pipe line as for the tankers and accessory facilities to transport an equivalent amount of energy.

tically to eliminate the production of residual fuel for uses where it does not command a premium over coal. (Residual fuel oil has superior value for some operations such as ship bunkering, open-hearth metallurgy, and apartment-house heating.)

Whereas coal will probably be the ultimate source of much of our liquid fuels, oil from coal will not be economic until major changes in oil refining and marketing, necessitated by the increasing cost of crude oil, have been pushed to the limit.

F) Availability During the Next 10 Years

The most competent published appraisals of liquid-fuel prospects for the next 10 years are in the "Report on the Long-Term Availability of Petroleum," prepared in November 1948 by a subcommittee of the API National Oil Policy Committee, under the chairmanship of L. F. McCollum. Its major conclusions, predicated on the existence of favorable economic conditions for private enterprise and assuming that crude production will not exceed maximum efficient rates, may be paraphrased as follows:

1) The availability of natural liquid hydrocarbons (crude petroleum and natural-gas liquids) produced in the United States will have increased by 1953 to 6,960,000 barrels per day, plus or minus about 5 percent, as compared to a 1948 estimated domestic production rate of 5,900,000 barrels daily (5,500,000 barrels of crude and 400,000 barrels of natural-gas liquids). Detailed estimates of domestic availability beyond 1953 are not warranted, but the committee does not anticipate a significant decline from 1953 to 1959.
2) Production of crude in the Western Hemisphere, outside the U. S., is expected to increase from 1,750,000 barrels daily in 1948 to 2,490,000 barrels in 1953, and in the Eastern Hemisphere (exclusive of Russia) from 1,500,000 barrels daily to 2,520,000 barrels in 1953. Both foreign sources are expected to increase further in the subsequent 5-year period and to represent additional supplies available to the United States.
3) Production of synthetics will be almost negligible through 1953; but operable processes have been developed, raw materials are available in large amounts, and the inception of significant production is contingent only upon the economic justification and the time for constructing facilities.
4) Larger quantities of natural gas will supplement liquid fuels.

IV.) DISCUSSION OF SUGGESTIONS

These considerations of liquid-fuel sources lead naturally to a discussion of various proposals for meeting the demands of a war emergency. Conclusions are summarized later.

There is rather general agreement that a vigorous and flexible oil industry, accustomed to quick adjustment to changing conditions, is the first essential. Its representatives should have a continuing active liaison with government, so that the country's state of readiness in fuel supplies is known to both. We cannot again afford the uncertainty, the misunderstanding, and the fumbling which characterized the military's early handling of petroleum problems before industry personnel had been effectively enlisted in government in the last war.

There is also general agreement that government should finance specific measures for security in liquid fuels only to the extent that they are found to be necessary, but to be unsound ventures for private enterprise.

A) Suggestions Dealing with Reserve Producing Capacity

The existence of a substantial North American reserve capacity to produce and refine crude oil at any time would offer the best physical assurance of liquid-fuel supplies. Many of the suggestions to be examined deal with this problem.

1) Developed oil fields which had been operating at low capacity or had been shut back, and which could be opened up at once in an emergency, would be ideal from the security standpoint. Several Texas fields, e.g., Friendswood, Conroe, and Hastings, exemplified this security ideal last time. But private capital cannot afford to bury money in developing new fields which it does not expect will show a return in the form of oil production until a war. Hence, the existence of this type of private excess capacity may be fortuitous—resulting from competitive enterprise's overshooting the mark in preparing for future demand. However, the expanding characteristics of the oil industry, which delivers products to almost every family in the country and which will go to extremes to satisfy its markets, means that some such overcapacity is normally to be expected.

It has been proposed that government pay the insurance cost of maintaining capacity in reserve by offering to buy fully developed oil fields which would then be shut down or operated under lease at very low capacity. Complete control of the pool would, of course, be essential. This would be an extension of the policy exemplified by the Elk Hills Naval Reserve, except that the pools would already be developed for quick production rather than held in an undeveloped and "unready" condition. (If such government reserves were acquired, they should be held for general wartime use, and not regarded as the property of one specific department.)

This concept of government reserve fields purchased from private owners (if more than half the interests wanted to sell) has been advanced as a balance against the effects of heavy imports. If government acquired and then shut back domestic fields which could produce substantially as much as our net imports, we might achieve the long-range advantage of conserving our own crude and at the same time protecting our fuel supplies over the short range against the loss of imports in war. Further, the market for domestic crude would remain strong, despite imports, because of government purchasing activity—thus maintaining the necessary incentive for active exploration.

But such a program would require heavy government investment. Thus, if imports increased to 2 million barrels daily, it might take something like 20 billion dollars to purchase domestic fields of equivalent producing capacity. The dollar investment should be sound enough because domestic crude oil will become increasingly valuable with time, but the implications of having government own almost half of our production capacity as a reserve are highly disturbing. Does the country have to pay such a price for insurance?

An alternate plan would be to leave field ownership in private hands and to have government pay a subsidy to the owners for shutting down the field for a fixed period of perhaps 10 or 15 years, unless war came sooner. The disadvantages of this scheme are similar in principle to those of government ownership.

Although some program of government purchase or subsidy for reserving "security oil" in domestic fields may merit thoughtful consideration a decade hence, it seems unnecessary to present planning in the light of other possibilities.

2) Fields which have been discovered but not yet developed can play an important role in increasing war output if advance planning has provided for their rapid development when needed. Under the spur of competition in a healthy producing industry, exploration and wildcatting are stimulated by the desire to find new oil before a competitor finds it. But no such haste need dictate heavy expenditures to develop the newly discovered field quickly, particularly if it can be unitized. Slow development of new fields is a positive contribution to security if the plans and equipment for a rapid acceleration are ready.

Two suggestions have been advanced as to how government aid might foster

a slower exploitation of new fields if economic forces and allocation practices do not prove adequate:

a) The field might be developed with government loans, on an agreement which limited production to a low rate for 10 or 15 years. The loans would start bearing interest when the production restrictions of the contract expired.
b) The field might be left undeveloped by agreement, and with government subsidy paid as "in lieu" of royalty on deferred production.

3) An economic climate which is favorable to vigorous exploratory activities *before* the war is the necessary prelude to adequate capacity *during* the war. This implies healthy rewards for finding oil. Exploration and wildcatting are so characteristically individual competitive enterprises that active government participation or financing would seem most unwise.

4) Both federal and state governments can strengthen our security in liquid fuels by further fostering conservation in production, especially by encouraging unitized field operation. State regulatory bodies in the Southwest have contributed greatly to the cause of conservation, but much more remains to be done. Practices which result in greater eventual recovery fortify our long-range position. Equally important may be practices, contingent upon unitized operation, which permit higher efficient producing rates.

5) Better information on the country's efficient capacity to produce crude is essential to better security planning. The current program of the Texas Railroad Commission to hear testimony and estaolish "maximum efficient rates" for the pools throughout the state should stimulate similar efforts elsewhere. Perhaps this should be an industry task in those regions where state bodies do not take the initiative. More emphasis on MER's will challenge the reservoir engineers to greater accomplishments in the efficient utilization of pool reserves and capacity.

Production can be increased for a time by disregarding ultimate recovery and by producing to the maximum. We all realize that this would be done in a crisis. But it would seem utterly unsound to plan emergency production on a basis which involves seriously injuring our fields for the future.

6) Specific projects to increase the efficient rate of production from given pools might contribute significantly in an emergency.

As an example, the current MER of the East Texas Pool is somewhere near 300,000 barrels per day (about 5 percent of U. S. capacity). It has been estimated that the injection of 500,000 barrels of water from outside sources, supplementing the present salt-water return to the field, would permit the efficient production of another 250,000 barrels of oil daily from East Texas. The capacity of the present salt-water disposal facilities would, of course, have to be enlarged. This seems to be a case where the government could install facilities as an emergency reserve for increasing production rates in war without interfering with peacetime operations and private ownership. The expense would probably not exceed $60 million, a cheap insurance premium for an increase of a quarter million barrels per day on demand.

Other projects of this nature to achieve greater emergency productivity can doubtless be developed. Some which are not economically justifiable in peacetime may yet permit greatly increased efficient rates which would warrant government construction for emergency capacity.

The question as to whether such government facilities to increase rates should be constructed or merely planned in peace is one of timing. If the specific plans and the necessary equipment were ready, installation might take only six to nine months. If that can be done, actual construction could be deferred until the emergency was evident.

7) The expectation of great oil development in western Canada warrants special discussion of its potentialities as a security reserve. Western Canada currently produces only 70,000 barrels per day, but various authorities estimate her probable reserves at between 5 and 20 billion barrels. Development of this huge region will probably be rapid at first, but will soon slow down. It is assumed that exploration and wildcatting will be vigorous over the whole area, but that field development will slacken after the first few years—awaiting the market demands which will justify development costs and pipe-line outlets.

Perhaps this natural process of letting things take their course is adequate. On the other hand, the usefulness of this oil when needed would be better assured if plans where made for quick production and transportation in an emergency. At a minimum, steel for field drilling and for pipe lines and pumps should be ready at the start of a war, destined for probable use in Canada. Possibly the preparations should go further. Promising fields which did not justify immediate drilling could be developed by government loans which would not bear interest until the fields went into production. Pipe lines could be constructed on the same basis. All phases of the problem of developing the potentialities of western Canada would require study, with particular regard to the time factor. The possibility of a million barrels a day from this source when needed is reassuring, but we must be sure that it can be made available in time.

8) The last item under "reserve producing capacity" deals with steel—steel for producing and steel for pipe lines. Oil production was never really critical in the last war. But ocean transport proved vulnerable in the early months, and was taxed to the utmost by war-theatre demands throughout the war—and it took a long time to build the Big Inch and the Little Big Inch. We may fairly anticipate that next time there will be emergency pipe lines and much field development to be done (particularly in Canada or other new areas). If the line pipe, the pumps, and the oil-field goods are already available, the jobs can be done quickly. This means carrying inventories—inventories which in many cases may be larger than the oil or the steel industry can afford.

During the war we made tremendous amounts of ammonia. The country's capacity was more than doubled, and the plants required heavy pressure equipment like that in oil refineries. Yet the construction of ammonia plants never required top priorities and fights between competing agencies. Why? Simply because a certain ordnance officer ordered his heavy reaction vessels and compressors in the summer of 1939.

A stock of the most necessary steel items for the oil industry, carried by government to the extent that it exceeds normal industry requirements, should be excellent insurance against a shortage of liquid-fuel supplies. The government should stockpile steel for oil production, pipelining, and refining when a slack develops in the demand for this type of product. Pipeline equipment is perhaps the most vital. The flexibility of having the materials ready for use where needed is all-important. This is an essential feature of a program to assure a quickly developable reserve capacity and availability.

B) Suggestions on Stockpiles of Oil

1) The accumulation and storage of very large volumes of products—up to 900 million barrels—during peacetime as a maintained war reserve has been discussed previously herein. It is technically feasible, and it would stimulate the expansion of production, transportation, and refining during the

years when it was being accumulated. It would be very expensive, however; and, in my opinion, it typifies a policy of "over-readiness," which is undesirable and unnecessary if plans are laid to convert quickly to a war economy when the emergency becomes evident.

2) The suggestion of stockpiling urgent war products which require considerable processing falls in a different category. (The atomic bomb is a prime example.) In the last war there were only three important petroleum specialties of this character: toluene, the synthetic components of aviation gasoline, and the components of synthetic rubber. Moderate stockpiles of toluene and of aviation alkylate seem reasonable, largely as a means of keeping manufacturing facilities activated.

3) The oil industry seems to be trying to get along with too little product storage capacity for its regular business. The shortage of present industry tankage is indicated by comparing the low point on total stocks of crude, refined products, and natural gasoline with the high point of such stocks since December 1946. Within this period there has been both a shortage threat, which aroused the industry to maximum efforts to avert it, and an oversupply condition, which resulted in reduced production and refinery runs. The low point on stocks was in March 1947, when the Bureau of Mines report showed 481 million barrels; the high was this summer, with 636 million barrels. The difference between high and low, representing the effective range of industry storage, is only 155 million barrels, or less than a month's supply.

A shortage of industry tankage would seriously hamper operations in an emergency. But this is not a case for government aid. It appears that the industry needs, and probably will provide, considerably more tankage for its regular operations.

4) It has been proposed that a reserve stockpile be created by importing and storing foreign crude. If it were to be stored aboveground so that it could be quickly available, the proposal corresponds to the product stockpile discussed previously herein except that the cost would be less, but there would be no peacetime stimulus to refinery capacity created by turning it into products. The suggestion that it be stored underground in depleted oil fields seems technologically less sensible than refining it for use as received and leaving an equivalent amount of producing capacity underground in our own oil fields.

5) The idea that liquid fuels should be rationed in peacetime as a move to conserve reserves has probably occurred at least once to most of us, usually after some irritating personal experience on the highway. But government restriction of fuel use is so repugnant to the free economy which we cherish, and it would so undermine the vigor of the oil industry, that it cannot be justified until the threat of impending war is clear and emergency stockpiling begins. Then the action should be prompt and decisive.

6) The most significant oil-stockpiling proposal seems to be to create a stockpile of products by quick and well planned action when the emergency becomes evident. Inasmuch as this has been discussed previously herein, it need only be repeated that rigorous rationing on a well devised plan should be instituted promptly, and that empty tankage, provided prewar at government expense, must be available to receive the first products for stockpiling while additional tanks are being erected.

7) This section on stockpiling would be incomplete without making a cross-reference to the value of stockpiles of steel for emergency pipe lines and for development drilling of oil fields.

In concluding the discussion of oil stockpiles, I feel that the storing of products or crude aboveground in large volume during peacetime in anticipation of a war in the indefinite future represents exorbitant and unnecessary insurance premiums for short-range security. A stockpile of products which will have tremendous value can be created when the emergency arises if adequately planned and courageously instituted.

C) Suggestions on Imports

Suggestions on imports range all the way from welcoming large volumes, and thereby reserving some of our own crude, to prohibiting them so that domestic discovery and development will be stimulated to the maximum. DeGolyer recognizes both these considerations in his statement before the Armed Services Committee in February, 1948: "My recommendation is that this nation import all of the oil that it can bring in without damaging its domestic industry, which is fundamental to it." The statements of the National Petroleum Council in "A National Oil Policy for the United States" emphasize protecting the health of the domestic industry by importing only as much oil as is needed to supplement domestic production.

No one individual can fairly determine the extent of imports which will best contribute to national security. In my view, short-range security in oil (over the next 10 years) may be impaired by heavy imports today, but longer-range security would be aided by a willingness to use larger imports than are now coming in. Eventually we shall want large volumes of foreign crude. To accept more now would lessen the shock of transition, and would have indirect but potentially powerful security benefits by encouraging world commerce and strengthening our allies. This is a broad policy issue which involves more than the single question of national security in oil. Restricting it to the oil security problem, it is felt that the calculated risk of some sacrifice to short-term security, because of the probability that imports will be greatly reduced in war, is justified by the longer-term benefits of a stronger domestic resource position and a healthier world economy in petroleum.

A somewhat similar philosophy may be noted in the policies of the Texas Railroad Commission in reducing allowable oil production when market demand shrinks. Such policies indicate a belief that the long-range interests of the state and of its citizens are best served by temperate exploitation of its exhaustible wealth.

Suggestions that oil imports be used to build product stockpiles, or that government purchase domestic crude reserves in an amount equivalent to imports, have been discussed previously herein. To me, they seem like compromises involving government intervention which would be unnecessary if the industry can adjust itself to heavier imports without slackening its domestic exploration. A significant reserve of domestic producing capacity should be recognized as desirable and normal. It is well to remember in these days of surplus that only two years ago we were faced with a shortage.

D) Suggestions on Synthetics

General interest in synthetic oil—from natural gas, shale, or coal—has slackened somewhat in the past year because of the improved crude-oil supply position, but the basic importance of oil from other than crude petroleum is really unaffected. Synthetics offer a domestic supplement to domestic crude supplies and, therefore, a security factor which foreign oil cannot provide.

From the earlier discussion, it is concluded that natural gas will not become an important source for liquid fuel because it is more valuable as gaseous fuel. Coal has eventual promise, but not until crude availability has decreased to the point where residual fuel oil to compete with coal has been eliminated as a refinery product. Shale

oil seems like the most immediate prospect.

Basic research on the problems of synthesizing oil is very much in order, both by industry and by government. As economic practicability becomes evident, private enterprise will assuredly embark on the large-scale development activities which are a necessary prelude to commercial operations.

Arguments that the oil industry will hesitate to venture on the construction of synthetic plants because of the heavy investment required, and that security will thus be prejudiced, have led to the suggestion that government finance full-scale commercial plants which will be ready to operate in an emergency. Such a plan assumes either that the emergency will bring a sharp restriction in crude supply, because of loss of imports, or a sharp increase in requirements which cannot be met by rationing and quick stockpiling, or both.

Building a reserve synthetic industry, which must stand essentially idle if it is to fulfill its purpose as a reserve, is estimated today to require an investment of the order of 10 billion dollars for a capacity of 1 million barrels per day ("Liquid Fuels from Coal and Oil Shale," by Roberts and Schultz, "Oil and Gas Journal," September 15, 1949). For orientation on such big numbers, the aviation-gasoline program of the last war required a little less than one billion dollars in facilities, of which three-quarters was for industry-owned plant. A full-blown synthetic industry in idleness would indeed be expensive insurance.

The logical program for synthetics would seem to be for government to concentrate on basic research, and for industry to develop and install the plants as economic need justifies. It is pertinent to recall that the oil industry is venturing in excess of a billion dollars a year in the necessary search for new raw materials.

E) Suggestions on Refinery Utilization of Crude

Up to now there has been mentioned the refiner's participation only by implication, as in the rapid building of product stockpiles at the start of a war, the modern prewar stockpiling of war specialties, the inadequacy of present industry storage facilities, and the expansion of East Coast refining to process imports. Of course, when a synthetic industry is built, it will be the product and the responsibility of the refiner. Also, reserve refining capacity is essential to security to almost the degree that reserve producing capacity is needed. It need hardly be mentioned that refineries to handle foreign crude should be on our own shores if we are to be fully assured of their contribution in a crisis.

But it does seem pertinent to discuss that aspect of refining which deals with yields.

The oil refiner attempts to process his crude oil in such a way as to secure the best net return from the sale of his products. These products can be classified roughly into "distilled" products, viz.: gasoline, kerosine, and distillate fuels; and "residual" fuel oil. Ideally, the refiner would like to maximize the yield of distilled products and not have to make any more residual fuel oil than is needed for quality uses such as bunkering ships. Actually, he is unable to do so because of processing limitations. "Resid" is a byproduct.

As crude becomes scarcer and, therefore, more expensive, the refiner feels increasing pressure to secure more distilled product yield and reduce "resid" production. Crude oil will become too expensive to run it into a low-grade byproduct. Improved processing is essential to survival in the competition.

This economic pressure is favorable to the long-term security interests of the country. Excess production of residual fuel oil is a waste of quality resources almost like flaring gas in the oil field. (Note that this residuum is superior to coal as a raw material for synthesis to gasoline by either Fischer-Tropsch or hydrogenation processes.) A number of processes for increasing distillate and reducing "resid" yields are operating today: coking, viscosity breaking, vacuum reduction, propane deasphalting, catalytic cracking, and even some hydrogenation. It is true that they require added refinery investment and operating cost, but these will be increasingly justified as crude becomes more scarce. Chester F. Smith ("The Future of Oil Refining," before the 14th Mid-Year Meeting of the API Division of Refining, April 6, 1949) concludes: " . . . our large supplies of residual fuel oil should be considered first as a better potential source of light products."

There have been many times in the past when a refiner could with profit buy and run cheap crude directly into residual fuel oil, which he then sold by under-cutting the price of steam coal. (This is true today with heavy foreign crudes, although we are not directly concerned with them at this point.) A definite advantage of high crude price is that it discourages such uneconomic use of oil and tends to stimulate more efficient refining.

Fundamentally, that type of refinery development which increases the economic yield of products which have unique values as liquid fuels contributes to security by conserving a quality resource for quality use.

V.) CONCLUSIONS

The preceding discussion points up a conclusion which we all instinctively recognize: absolute security is a myth —we must choose between "insecure" alternatives. The following measures seem most promising:

1) Foster the continuing existence of reserve capacity to produce crude in an emergency by:

a) Active research to develop new and better methods for finding oil.
b) High exploratory activity—incited by healthy rewards for finding oil.
c) Restricting production from new fields.
d) Encouraging unitization—which requires state and/or federal cooperation.
e) Obtaining better information on the country's existing capacity to produce—its true "maximum efficient rate" at any time.
f) Developing specific projects which will result in greater efficient production in an emergency as well as those which increase ultimate recovery.
g) Developing the potential western Canadian fields and other new domestic areas as emergency reserves until their production is needed for peacetime uses.
h) Stockpiling oil-field and pipe-line steel.

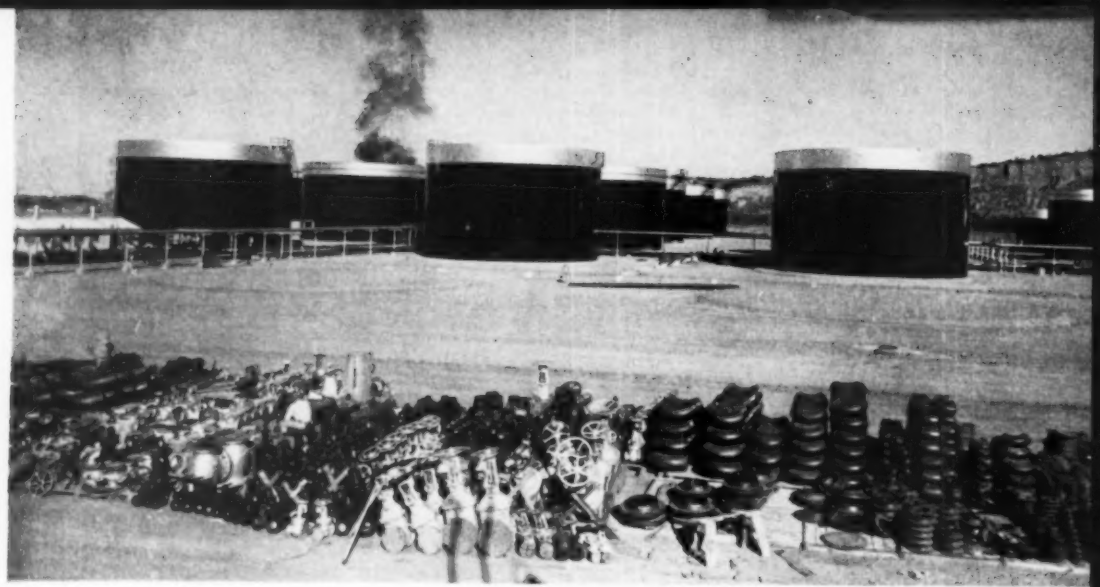
2) Plan to stockpile oil products at the start of the war by rationing at once and running the products of rationing into empty tankage, some of which has been provided by government in advance. In addition, industry will contribute to security by erecting the additional tankage which it really needs for its normal operations.

3) Import as much oil as can be accepted without serious prejudice to domestic exploratory activity.

4) Develop synthetics by private enterprise, assisted by basic government research.

5) Develop refinery flexibility to permit higher yields of distilled products.

In the very nature of oil production, long-term future supplies are unpredictable, but any rapid loss of producing capacity is most improbable. Faith that an industry which has so adequately demonstrated its ability to meet demands in the past will continue to do so in the future should be accompanied by continuing close liaison with government in its defense planning. If this be done, the present conclusion that government projects need not extend beyond basic research, detailed planning for emergency stockpiles and production increases, and modest prewar provisions for stockpiling steel and war specialties can be intelligently modified when and if necessary in time to assure constant preparedness in liquid fuels.



Innumerable Tasks and Operations Go to Make Up Modern Refinery

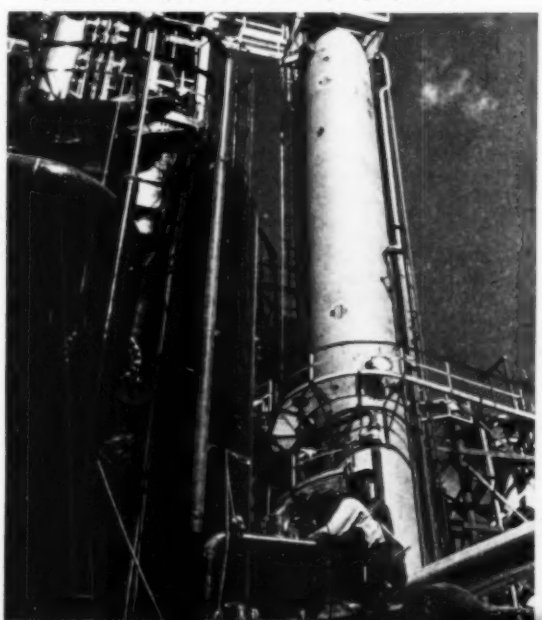
Conoco's New Plant at Billings, Mont.

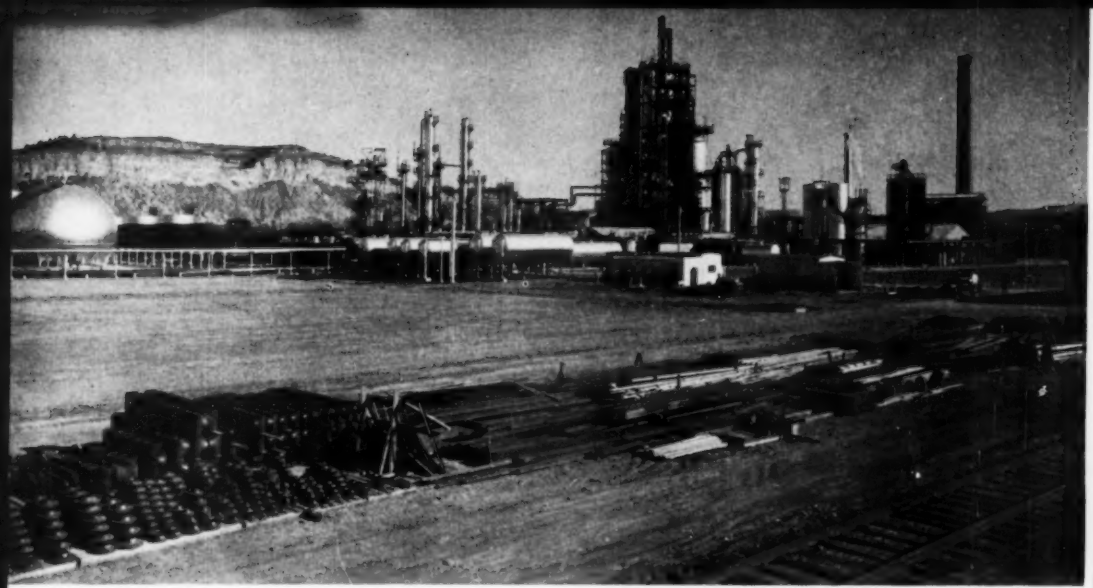
CONTINENTAL Oil Company formally opened a new refinery at Billings, Mont., last month. The 7550-barrel-per-day plant, which cost $9.5 million, includes crude oil distillation, propane de-asphalting, fluid catalytic cracking, fluid catalytic desulfurization, catalytic polymerization, and liquefied petroleum gas facilities. Because the plant incorporates ingenious and promising new process schemes designed for the more effective handling of high-sulfur (2.2 weight percent in feed stock) crude oils, the operating results attained will be a matter of considerable interest to the refining fraternity.

A description and process flow diagram of this complete

Structural workers play an increasingly important part in refinery construction. Large steel support and service structures came into general use with the advent of the catalytic cracking units and the modern high capacity distillation units. This particular structure includes an elevator for freight and passenger service. The workers (photo below), who seem to be in precarious positions, actually are working safely enough—but must stay alert. When the unit is finished, broad platforms, walkways, caged ladders, and guard rails will provide access in complete safety to all levels of the structure, thus facilitating plant operation, equipment inspection, and maintenance.

Welders, shown in photo below, are vitally important in the fabrication of modern process units. They must be highly skilled, of course, so as to produce uniform leak-free welds of high strength. Their abilities are established and maintained at a high level by periodic strict test weld inspection procedures. Welding today is the principal fabrication method for refinery vessels and piping. Without the resulting leak proof and rugged equipment many of our processing that require severe operating pressures and temperatures would be completely impractical.

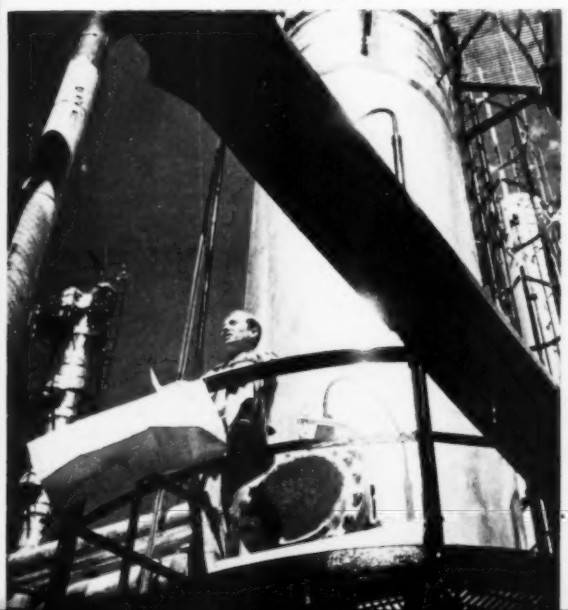




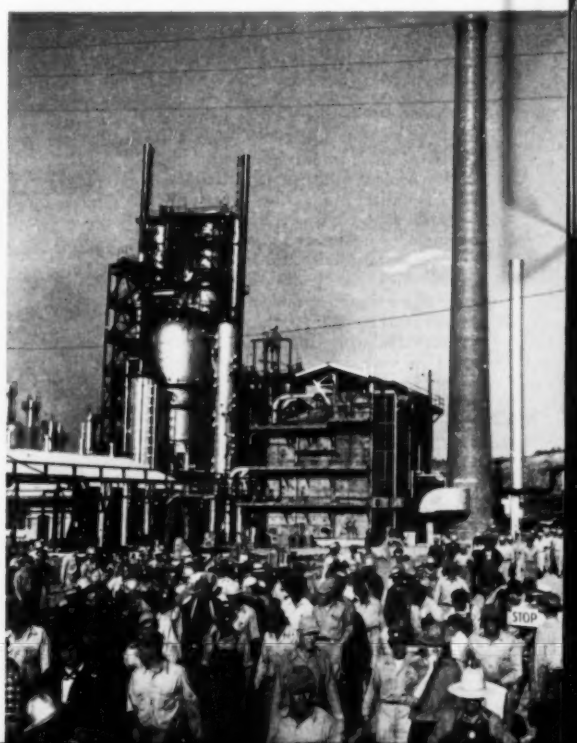
The plant, at this distance (photo across top of this and page oppos.te/, seems to be well advanced in construction. Even casual inspection shows that a whole lot of the piping was in place when this picture was made—but the stacks of valves and fittings and pipe in the foreground, unloaded by the railroad siding for movement to the process area as needed, are just a part of the large quantities of equipment items and materials that will be used to finish building the refinery.

plant was published in the April, 1949, issue of PETROLEUM REFINER. In that story, several photographs of the process areas served to indicate the arrangement of equipment. The photographs here are a little different. The photographer who made the contractor's "construction progress" shots also made occasional random photos of craftsmen and engineers at work, and "pattern" shots of stacks of fittings and building materials awaiting fabrication—whatever he saw that interested him. Some of these, assembled, convey a rather clear impression of the tremendous amount of work, the amazing number of individual tasks and operations and individual equipment components that make up a modern refinery.

In photo below an engineer checks construction progress against a working drawing. Literally boles of such drawings enter into the building of a refinery—and needless to say, each detail of each drawing must be precisely carried out before the plant is complete. Check, and check, and fix-if-need-be, and check again, month after month after month—for roughly two years.



Refinery builders include most of the crafts—masons, concrete workers, pipefitters, welders, electricians, carpenters, steel workers, boilermakers, insulators, painters, riggers, and a host of others. Since much of the work to be done can be performed simultaneously at various different points, large construction crews are the rule during the peak period of each project. The workers are scattered during the work day, however, and the chance observer may not appreciate the number of men involved—unless he happens near the project at quitting time (photo below). Day's over—let's go!



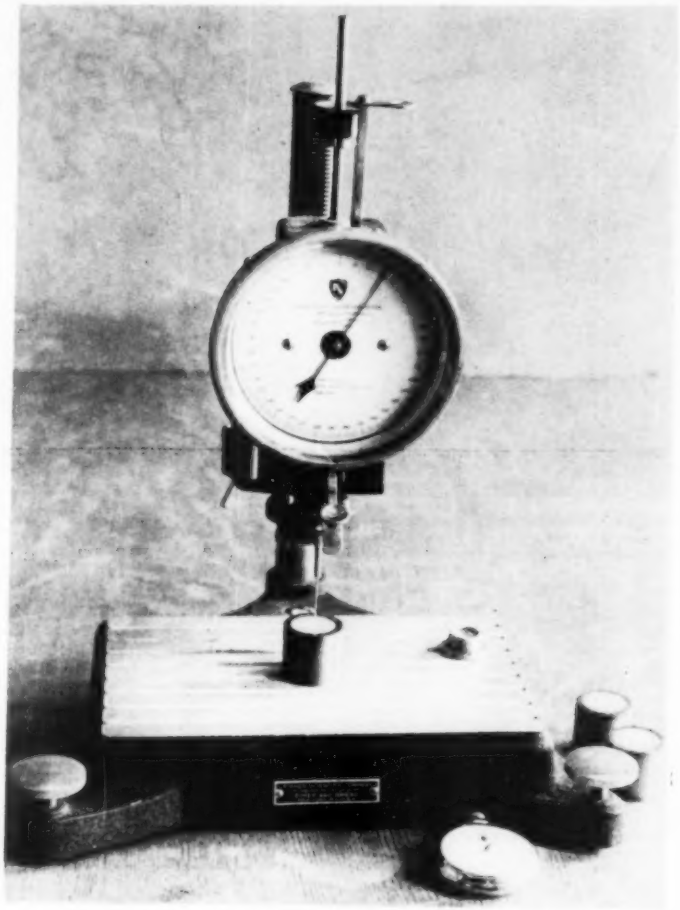


FIGURE 1
Standard ASTM Penetrometer Adopted for the Test of Waxes Described in this Paper.

THE OPERATOR'S control of a process can be no better than the routine test methods available for checking products and intermediate materials. This article reports a rapid method for determining the penetration of waxes. Like several earlier articles, the work is an account of the continued efforts of the authors and their colleagues to develop standards for testing petrolatums, waxes, and specialty products. Their pioneer work should prove useful to many in the industry.

A Micro Penetration Test for Waxes

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ONE of the physical properties by which petroleum waxes and especially microcrystalline waxes are judged is the hardness as expressed by the penetration or consistency, and refinery operations are usually run under conditions which will yield a wax meeting definite penetration specifications. Test samples are taken at intervals to insure that manufacturing conditions are correct. It is essential that the results of the test be available as quickly as possible since plant operations usually cannot be stopped while the test is being run. It is also important to be able to determine the penetration when only a small sample is available for testing or matching.

However, no reference could be found in the literature to a rapid method for determining the penetration of waxes or for testing small wax samples. Indeed the only published test in general use is the ASTM Method D5-25 which requires a comparatively large sample, two hours for testing, and which was not even originally intended for waxes—it was developed for testing bituminous materials. It is the purpose of this paper, therefore, to describe a rapid method for determining the penetration of waxes which is suitable for use as a control and referee test.

The ASTM D5-25 method determines the penetration of bituminous materials by measuring the distance which a free-falling, weighted needle penetrates the sample under standardized conditions. The penetrometer specified by the method is an accurate and convenient device and the method has found widespread use in the petroleum industry for measuring the penetra-

FIGURE 2A

FIGURE 2B

FIGURE 2C

tion of waxes. However, this method has three shortcomings:

1) It requires too long a period for completion.

2) The surface of the sample when treated according to the D-5 method is concave **(Figure 2A)** thereby introducing a source of error, which gives results slightly higher than theoretical.

3) Despite the desirability of placing the sample container under water when running the penetration test, samples of light colored waxes do not reflect the needle image as is the case with bituminous materials. For this reason it is impossible to use the ASTM D-5 method ad litera, since the point at which the needle touches the surface of the wax can not be determined under water.

Standard ASTM Penetrometer

Since the shortcomings of the method are not due to the penetrating device, the standard ASTM penetrometer was adopted for the method described in this paper **(Figure 1)**. The reason why the ASTM method requires two hours is that the relatively large samples takes a long time to attain the temperature of 77° F. at which the penetration test is run. It will be shown in Table 1 that even the two-hour cooling period is not sufficient to insure that no further variation in penetration with time occurs.

Preliminary work was done to determine whether a large sample has any advantages. Penetrations were made along the surface of the sample, from the center to within ¼-inch of the side of the container and all results were practically identical. It could then be safely assumed that a large sample offered no advantages since proximity to a container wall did not affect the results. The development of a penetration test for waxes, therefore, consisted in evolving the correct sample size and shape and in producing a plane sample surface.

TABLE 1
Influence of Cooling Time on Micro Penetration

Water Cooling Time* at 77° F. Hrs.	Microcrystalline Wax B ASTM D-5 Penetration 30			Paraffin Wax B ASTM D-5 Penetration 12		
	Micro			Micro		
	Top Surface	Bottom Surface	ASTM	Top Surface	Bottom Surface	ASTM
0.25	32	29	....	14	13	....
0.5	28	27	....	14	11	....
1	27	25	30	13	10	12
2	27	25	29	13	10	11
4	28	25	28	13	11	11
16	....	....	28	....	....	11

* Water cooling was preceded by a 15-minute air cooling period in the case of the micro penetration and by a 1-hour air cooling period in the case of the ASTM method.

To be successful, the method had to meet the following requirements:

1) It had to be reproducible.

2) It had to take less than two hours to run, the time required by the ASTM method.

3) It had to yield results which are the same or close to those obtained using the ASTM D-5 method. This requirement was included because a large percentage of the industry now uses the ASTM method, and much inconvenience which is caused by change in specifications is avoided.

Micro Penetration Container

Since all waxes tend to contract sharply on solidification[1] it was found that a plane surface could not be produced by the usual cooling procedures, especially when small containers were used, since the smaller the container the deeper is the concavity in the surface **(Figure 2B)**. Accordingly it was decided to use metal cylinders open at both ends and resting on glass plates, slightly moistened with a 50 percent glycerine solution in water. Wax samples which were poured into such containers were allowed to solidify and when the glass plates were slid off, it was found that the surface adjacent to the glass was flat and smooth **(Figure 2C)**. Further preliminary work showed that cylinders made from 1-inch standard brass pipe, 1¼-inch high, were of convenient size from the viewpoint of rapid cooling and ease of removal of the glass plate. Because of the high contraction of waxes, the solidified sample is liable to detach itself from the brass cylinder walls, and to prevent any slippage of the sample a few screw threads are cut into the center part of the cylinder walls **(Figure 3)**. Cylinders such as have been described yield a surface large enough to permit at least three tests and require only 10 cc of the wax to be tested.

Samples of waxes were poured into the brass containers, allowed to cool for 15 minutes at room temperature, and then immersed (with the glass plates still acting as container bottoms) in water at 77° F. for varying time intervals. Penetration tests were made on the original top surface of the samples and on the flat surface formed when the glass plates were removed. Other samples of the same waxes were tested according to the ASTM D5-25 method, except that penetrations were not made with the samples kept under water as specified by the ASTM method due to the difficulty in observing when the needle touched the sample surface.

All penetrations were made with the

standard needle under a load of 100 g for 5 seconds (Table 1).

The data in Table 1 show that a 15-minute air cooling followed by a 15-minute water cooling period yields results which check very closely with the ASTM method requiring a 2-hour cooling period. The results, however, drop slightly as the water cooling period is increased to 1 hour, after which they remain constant. The results by the ASTM method also drop as the cooling period is extended beyond the specified time. Consequently the 15-minute water cooling time was used as the basis for the micro test for two reasons: 1) It is quick; and 2) It gives results practically identical with the ASTM D-5 test.

It is to be noted that the top surface yielded higher results than did the bottom surface (that is, the surface adjacent to the glass plate). This is no doubt due to the fact that the top surface was concave and the needle penetrated a sloping surface which "gave" in the direction of the slope.

Micro Penetration Test
Apparatus Required

1) Penetration apparatus meeting the ASTM D5-25 requirements (Figure 1).

2) Penetration needle meeting ASTM D5-25 specifications, made from a cylindrical steel rod.

3) Sample containers. The containers in which the samples are tested are brass cylinders open at both ends having a 1-inch inside diameter, 1¼-inch height, and ⅛-inch wall thickness. The edges of the cylinders are ground flat in order to prevent leakage of the sample between the cylinder and the glass **(Figure 3)**.

4) Glass plates (microscope slides 2 x 3 inches are convenient for this purpose).

5) A water bath kept at 77° F. ± 1° F.

Procedure

Place several brass cylinders (sample containers) on glass plates which

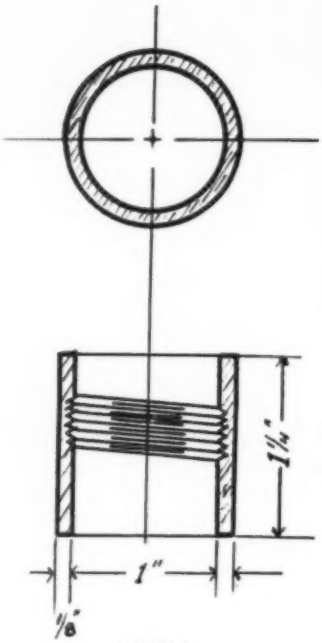

FIGURE 3

have been moistened with a 50 percent solution of glycerine in water. Pour the sample at 180° F. or 30° F. above its melting point, whichever is higher, into these cylinders. As the brass cylinders have flat edges, the sample will not leak out between the glass plate and the container wall. After 15 minutes' air cooling, immerse the samples with the glass plates still acting as container bottoms in the water bath kept at 77° F. ± 1° F. for 15 to 20 minutes.

At the end of the specified cooling time, the container is removed from the water bath, the glass plate is slid off the brass cylinder, and this end is now taken as the surface on which the penetration is run. It has no concavity while the other surface is decidedly concave (Figures 2B and 2C). Penetrations are made with the needle under a moving load of 100 g. for 5 seconds. At least three tests are made at points approximately ¼-inch from the sides of the container and at least ¼-inch apart. After each test the sample is returned to the water bath and the needle carefully wiped with a clean cloth to remove traces of adhering wax. The penetration to be reported should be the average of at least three tests which do not differ by more than three points between the maximum and minimum.

Experimental Data

Various samples of micro- and macrocrystalline (paraffin) waxes were tested by the micro method and by the ASTM D5-25 method. The data in Table 2 show that in all cases the micro method checks within two points of the ASTM method.

TABLE 2
Rapid Micro Penetration vs. ASTM Penetration

SAMPLE	Micro Penetration	ASTM D5-25 Penetration
Paraffin Wax A	10	10
Paraffin Wax B	13	12
Paraffin Wax C	16	16
Scale Wax A	30	32
Microcrystalline wax A	22	24
Microcrystalline wax B	29	30
Microcrystalline wax C	34	36
Microcrystalline wax D	41	42
Microcrystalline wax E	52	50
Microcrystalline wax F	55	55

Summary

A rapid micro method for the determination of the penetration or consistency of petroleum waxes is described. The method utilizes the ASTM needle and penetrometer but requires a smaller sample and less time. It yields results which are within two points to those obtained by the ASTM method.

LITERATURE CITED

[1] Kinsel, A. and Phillips, J., Industrial and Engineering Chemistry, Analytical Edition, **17**, 152 (1945).

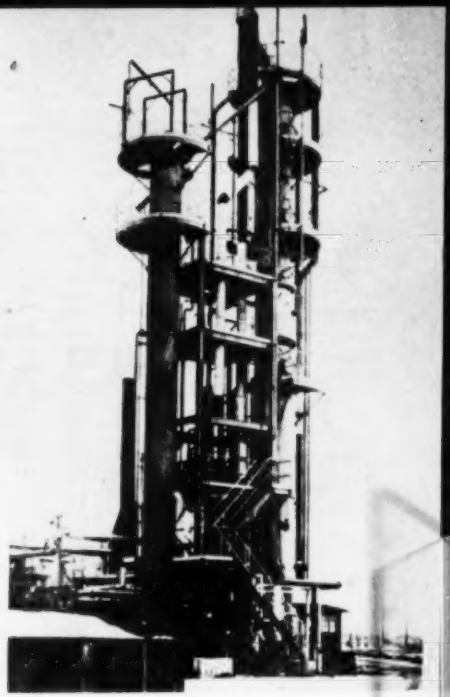

Figure 1. View of Commercial Hypersorber at The Dow Chemical Company, Midland, Mich.

The Hypersorption Process For Separation of Gasses and Vapors

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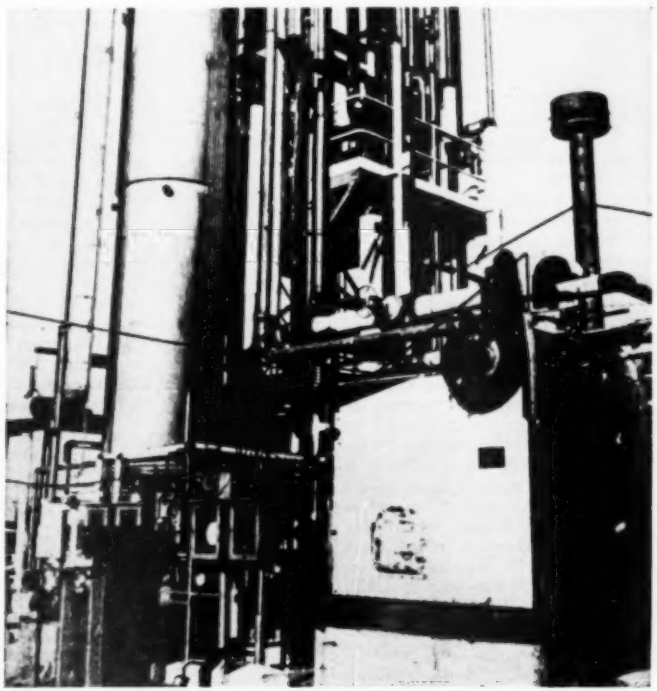
Figure 2. View of Commercial Hypersorber at The Dow Chemical Company, Midland, Mich.



THE Hypersorption process, now gaining importance in commercial operations, is capable of effecting separations and recoveries of light gases which were previously considered to be uneconomical. This process gains its advantage by employing a moving bed of activated carbon to absorb hydrocarbons out of lean gas streams. Activated carbon has a pronounced selectivity for the adsorption and retention of relatively large quantities of volatile hydrocarbons at low pressure.

Utility Economy

The major utility economy effected by employing activated carbon has been one of the basic justifying factors for the development of the Hypersorption process. The simplification of the processing operations involved in the separation of gases by the continuous adsorption cycle has contributed still further to the economy of this process by greatly reducing required capital investments.

The assembly details of a typical Hypersorption unit are shown in Figure 3. General construction resembles that of a fractionating tower with the addition of accessory equipment to effect transfer of solids from bottom to top, and to provide storage. Figure 4

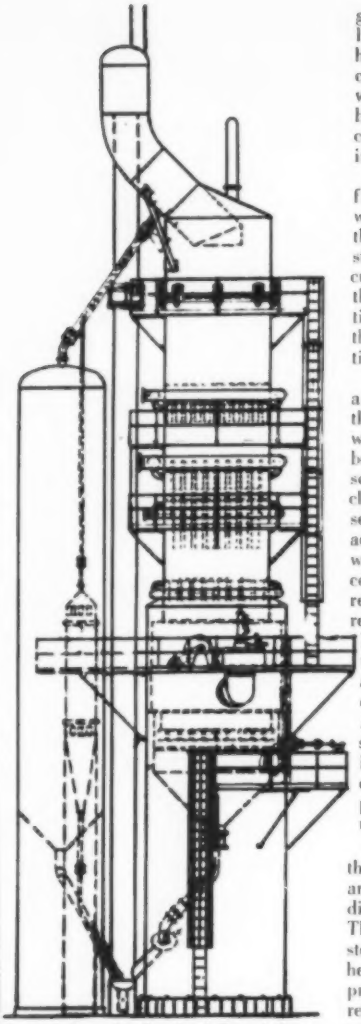


Figure 3. Assembly Details of Typical Hypersorption Unit.

illustrates in greater detail the processing operations associated with the Hypersorption unit.

Assembly and Operation

The Hypersorption unit comprises two major heat transfer sections, consisting of vertical tube in shell exchangers, separated by adsorption and rectifying sections with internal tray construction for introduction and takeoff of the various gas streams. These components are assembled to form one vertical cylindrical column with a cooler at the top and stripper at the bottom. A gas lift system is incorporated for the transfer of the carbon from the bottom to the top of the unit.

The unit is filled with a bed of granular activated carbon, the upper level of which is maintained in a hopper at the top of the unit. This continuous bed slowly moves downward and the circulation is controlled by the rate of release of the activated carbon from the base of the column into the lift system.

The activated carbon passes down from the hopper through vertical tubes where it is cooled prior to entrance to the adsorbing sections below. A gas stream simultaneously flows countercurrently to the carbon passing through the cooler and serves to remove effectively any water vapor retained on the carbon from the stripping operation.

The feed gas is introduced through a distribution plate near the center of the adsorption section and passes upward countercurrently to the moving bed of activated carbon. The unadsorbed lighter components are discharged at the top of the adsorption section just below the cooler. The activated carbon below the feed point, which contains the adsorbed heavier components, passes downward to the rectifying section where it contacts a reflux of heavy constituents liberated by the stripper at the bottom of the unit. This reflux serves to liberate any lighter constitutents which may contaminate the adsorbed material. A concentration of intermediate constituents in the vapor phase develops in this section, and if desired, a disengaging tray may be located at this point and the intermediate constituents produced as a sidecut.

The activated carbon flows down through a lower disengaging section and into a short steaming section directly above the stripper proper. There it meets an upward flow of steam which liberates the adsorbed heavier components. These are either produced as bottom product gas or returned to the rectifying section above as reflux.

Steam introduced below the stripper passes countercurrent to the activated carbon in the vertical stripper tubes, through the steaming section and is discharged with the bottom product gas. There is a gradual increase in temperature of the carbon throughout the steaming and stripping section, the highest temperature being attained at the base of the stripper. Most of the adsorbed materials are removed before the carbon passes through the stripper tubes proper. The flow of activated carbon leaving the base of the unit is controlled by means of a specially designed feed mechanism which gives positive control of the flow distribution in the cross section of the unit. The activated carbon drops from this mechanism into a sealing leg which restricts the flow of steam into the lift system. The activated carbon is transported to the top of the Hypersorber by a gas lift and drops into the hopper located at the top of the unit.

For the purpose of maintaining a high level of activity, a reactivation unit is provided. A small stream of carbon circulates through this unit in parallel with the Hypersorber and a high-temperature, steam-stripping operation is carried out to remove any accumulation of heavy residual hydrocarbons on the adsorbent.

The adsorption of gas on activated carbon is exothermic, and the heavier components are adsorbed with greater liberation of heat than lighter constituents. Thus the composition of the materials being adsorbed at any given point is characterized by the temperature of the activated carbon bed. Control of the separation in the Hypersorption unit utilizes this principle.

The side cut and bottom make gas streams are governed by automatic temperature controllers which operate on the sharp temperature rise corresponding to the separation points between the various components being processed.

Variations in Design

The general construction of the Hypersorption unit is varied from case to case to suit the processing conditions involved. Figure 4 illustrates construction wherein three product streams are made, top, side cut and bottom. In the case where extremely lean gas is being processed, the construction may be modified to employ two or more feed trays, as illustrated in Figure 5. The

***THE HYPERSORPTION** process for the separation of gases and vapors is of high current interest to the operators and designers of hydrocarbon process plants. There are now two units in commercial operation and a unit is under construction to recover propane from a large volume of natural gas. Other units for a number of applications are in various stages of engineering. This report, presented before the annual convention of the Natural Gasoline Association of America, in Fort Worth, is a review of the present status and possible applications of the process.*

use of multiple feed trays increases the capacity of the unit approximately directly as the number of such trays. It is particularly useful in applications as processing of lean natural gas, propane recovery and processing of coke oven gas for ethylene recovery. The side cut construction employs a separate internal stream of carbon to fractionate this side product to obtain a composition free of both lighter and heavier contaminants.

Engineering of the Hypersorption process has involved the development of a number of specialized mechanical designs. The basic concept of the design of the Hypersorption unit is predicated upon positive control of the motion of solids in the unit. All the flow paths have been designed so as to be symmetrical across the area of the unit and to permit vertical downward motion of the solids with minimum opportunity for channeling or unequal flow distribution. The engaging and disengaging trays are constructed with a similar view and consist of circular plates having symmetrically spaced downspouts through which the solids pass and under which the gases are permitted to engage or disengage. The flow-control mechanism, of the positive displacement type, assures equal flow of solids throughout the cross-sectional area of the unit.

Engaging and Disengaging Trays

In Figure 6 is illustrated the typical construction of the engaging and disengaging trays employed in the Hypersorption unit. These trays have a number of geometrically arranged downspouts which serve to conduct the solids downward in a uniform manner throughout the cross-sectional area of the tray. Disengaging of the gases occurs underneath the trays and the respective amounts of area inside the tubes and outside the tubes are proportioned in accordance with the flow quantities of gas either disengaged or fed upward in the unit through the downspout section. A number of inlet or outlet points is employed to minimize pressure drop in the gas distribution across large diameter trays. Figure 7 presents a photograph of a disengaging tray in the shop prior to installation.

Figure 8 illustrates a flow-control mechanism. It consists of a circular tray supported at three points and given an oscillating motion. This tray has a number of downspouts which serve as pockets for the conveyance of solids. These downspouts are so aligned with corresponding tubes and slots in stationary trays above and below that half the downspouts are filling and half discharging at each end of the reciprocating stroke.

A photograph of the feeder tray in a commercial unit is shown in Figure 9. Figure 10 presents a photograph of the commercial Hypersorber vessel.

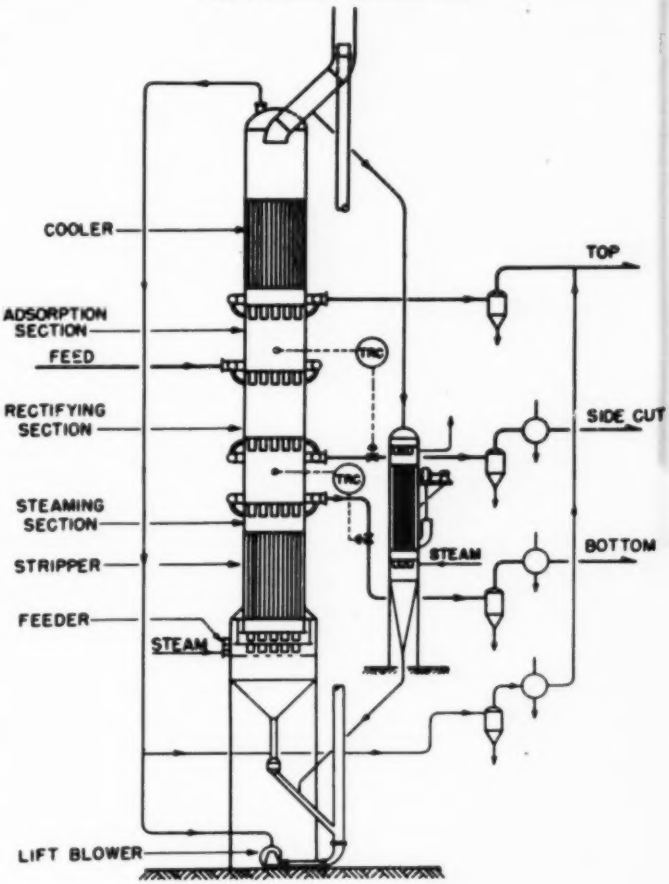
Stagewise Separation Effects

The separation of gases over activated carbon is a fractionation process involving the countercurrent contacting of the components in two phases and is quite analogous to the conventional multicomponent fractionation processes. The factors of reflux ratio, stage number, and variable molal flow of phases are of importance together with the controlling adsorption effects of activated carbon which dictate the relative volatility of the components and thereby the separations occurring in each stage of contact.

The design of a given column for the separation of a gas mixture reduces itself to a calculation analogous to that involved in multicomponent fractionation for the case of variable molal overflow with the added variable of change in relative volatility of the components in each stage as a function of the quantity and composition of the adsorbed phase. The results of these calculations are entirely analogous to those obtained in fractionation, and for every separation there is a minimum reflux ratio and minimum number of stages required.

In Figure 11 is presented the plot of stagewise calculations evaluating the separation between ethane and propane in a Hypersorption bed, feeding a lean gas stream consisting largely of methane and C_2's, with heavier components being present in a relatively small quantity. The compositions in the feed and production streams are presented in Table 1.

Figure 4. Diagram of Hypersorption Unit.



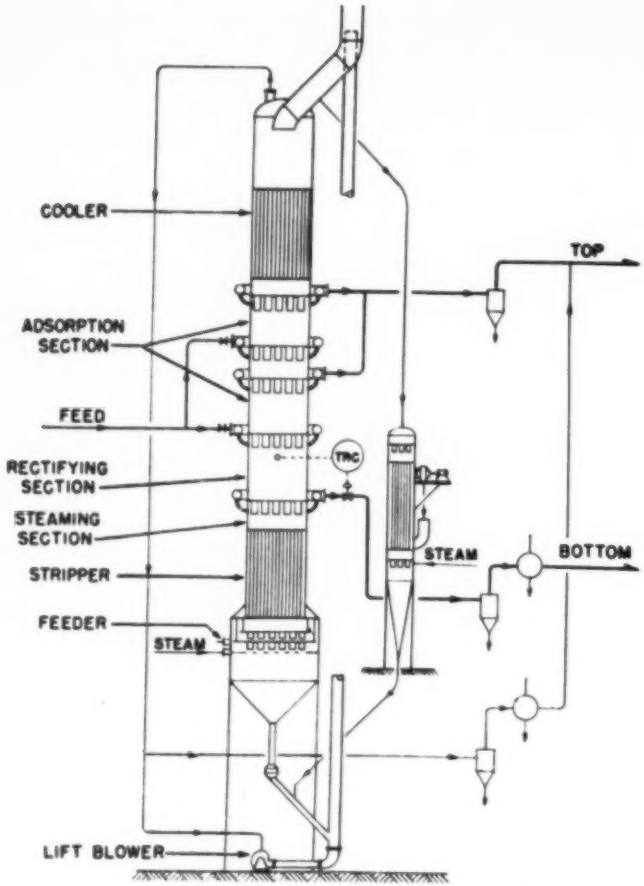


Figure 5. Diagram of Hypersorption Unit With Double Feed Inlet.

TABLE 1

Results of the Plate to Plate Calculation for Separation of Ethane and Propane in Hypersorption

Composition—Mole %

COMPONENT	Feed	Discharge	Make
CH_4	88.0	90.65	.....
CO_2	4.8	4.63	.....
C_2H_6	4.8	4.62	0.33
C_3H_8	2.7	0.10	89.37
C_4H_{10}	0.3	.....	10.30

Feed	100 moles
Discharge	97.09 moles
Make Gas	2.91 moles

Design of a commercial unit combines both pilot plant experimental evaluations and the theoretical analysis illustrated above.

Activity of Carbon Utilized

Commercial Hypersorption operations have shown virtually no deterioration in activity of the carbon employed. Pilot plant operations previously established the ability of the reactivation operation to remove accumulations of absorber oil and polymers of heavy di-olefins where necessary. The performance of the reactivator in commercial operations has confirmed pilot plant studies.

Attrition losses in circulation of activated carbon in the Hypersorption unit are very low because of the free-flowing nature and homogeneous structure of activated carbon grains. The gas-lift system employed in the unit has no curves or bends which would cause direct impact of suspended solids against the pipe wall. In the separation of the suspended solids from the gas stream, a specially designed impactless separator is employed, which serves to remove solids from the gas stream without direct impact against the steel wall. The activated carbon employed in the Hypersorption unit has a mesh range of 12 - 30 Tyler screen series when charged. Screen analysis of a typical charge is presented in Table 2.

TABLE 2

Screen Analysis of Typical Charge of Activated Carbon

TYLER SCREEN SIZE	Weight Percent Retained
12	0.2
20	68.2
30	27.1
35	1.8
60	1.5
Through 60	1.2

This material has a bulk density of about 29 pounds per cubic foot. As the carbon is circulated, the density increases to approximately 35 pounds per cubic foot. This is attributable to the re-distribution of the mesh range and development of particles which are more nearly spherical. The screen analysis of a charge after equilibrium is attained is presented in Table 3.

TABLE 3

Screen Analysis of Activated Carbon at Equilibrium

TYLER SCREEN SIZE	Weight Percent Retained
12	0.7
20	82.2
30	27.3
35	8.2
60	9.6
Through 60	2.0

Commercial Performance of Unit

The first Hypersorption unit constructed was located at Midland, Mich., and was built to recover ethylene normally lost in the demethanizer column overhead stream in the low temperature fractionating unit.[1] This Hypersorber unit processes approximately 1.8 million standard cubic feet daily of gas at 75 psi, and employs a carbon circulation of 18,000 pounds per hour and a carbon stripping temperature of 500°F. The Hypersorption unit is approximately 85 feet high and 4½ feet in diameter. A vertical bin 4 feet in diameter, 60 feet high, provides storage facilities for the carbon charge during shutdown.

The temperature gradient in the Hypersorption unit during normal operating conditions is illustrated in Figure 12. It will be noted that the temperature at the top of the carbon bed is about 120°F. and increases to 150°F. upon adsorption of heavier components of the feed gas. The temperature increases still further to 210°F. in the section where ethylene is being refluxed and then to 365°F.

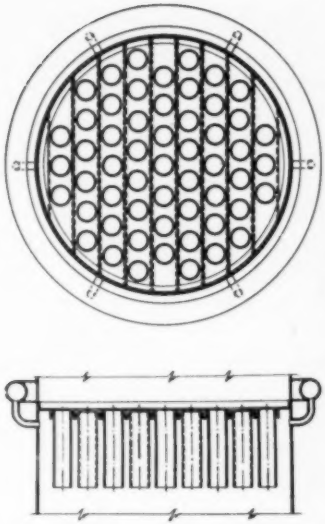


Figure 6. Engaging and Disengaging Tray Construction.

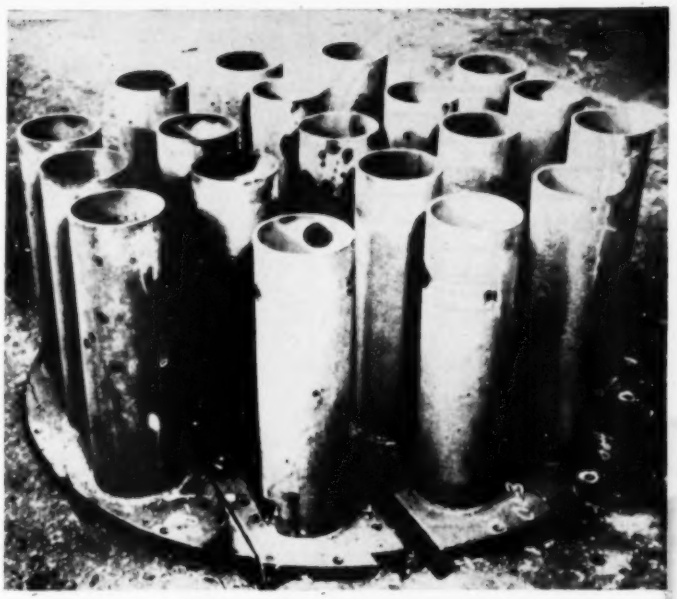


Figure 7. Shop Photograph of Disengaging Tray.

where steam adsorption occurs. The carbon reaches a maximum temperature of 500°F. in the stripper.

The separation effected in this unit is given in Table 4.

This plant has consistently recovered approximately 98 percent of the ethylene in the feed stream. A study of the material balance indicates that the small loss which occurs is entirely in the purge gas flow. The ethylene content of this stream is due to leakage of lift gas blower seal gas which has the same composition as the feed to the unit.

The utilities employed in this plant are presented in Table 5.

TABLE 5

UTILITIES IN DOW HYPERSORBER OPERATION

	°F.
Carbon Hopper above cooler	405
Carbon leaving cooler	120
Carbon above stripping section	365
Carbon leaving stripping section	510

Under these conditions the following utility rates were obtained:

COOLING WATER
(20° F. Temperature Rise)

	gal./min.
Hypersorber cooling section	135
Bottom product cooler	55
Lift gas blower seal	2
	192

FUEL GAS
(Lower Heating Value of 800 Btu./SCF)

	SCF./hr.
Dowtherm Vaporizer	2950

STEAM
(psig.)

	lbs./hr.
Stripping steam to Hypersorber	400
Turbine drive on lift gas blower	960
	1360

ELECTRIC POWER

	kw.
Water booster pump	2.5
Hydraulic pump for carbon feeder	3.5
Lighting, instruments, etc.	5.0

OPERATING LABOR

1/2 man/shift 12 man-hr./day

TABLE 4

Feed and Product Compositions, Material Balance

COMP.	FEED GAS		MAKE GAS		DISCHARGE GAS		PURGE GAS	
	SCF/Hr.	Mol Percent	SCF/Hr.	Mol Percent	SCF/Hr.	Mol Percent	SCF/Hr.	Mol Percent
H_2	29,400	39.8	.....	.....	14,200	31.6	15,200	61.8
N_2	1,240	1.7	.....	.....	630	1.4	610	2.5
CO	670	0.9	.....	.....	350	0.8	320	1.3
O_2	100	0.1	5	0.1	45	0.1	50	0.2
CH_4	37,900	51.3	.....	.....	29,600	66.1	8,300	33.7
CO_2	150	0.2	130	2.9	.....	.....	20	0.1
C_2H_2	160	0.2	160	3.6	.....	.....	.....	.....
C_2H_4	4,250	5.8	4,150	92.7	.....	.....	100	0.4
C_2H_6	30	Trace	30	0.7	.....	.....	.....	.....
	73,900	100.0	4,475	100.0	44,825	100.0	24,600	100.0

Applications of Hypersorption

Recovery of Propane and Butane

One of the major applications of Hypersorption is the recovery of propane and butanes from natural gas. Due to the high adsorptive attraction of activated carbon for these hydrocarbons, it is possible to process gas streams containing as little as 1½ volume percent of propane and effect of 98 percent recovery of the propane and heavier material. A material balance showing product compositions for a typical propane recovery application is presented in Table 6.

TABLE 6

Propane Recovery Material Balance

	Feed Mol Percent	Overhead Product Mol Percent	Propane Side Cut Mol Percent	Bottom Product Mol Percent
CH_4	78.1	81.5	....	....
C_2H_6	13.4	18.30	0.4	....
C_3H_8	6.9	0.2	98.4	0.8
C_4H_{10}	1.3	....	2.9	81.1
C_5+	0.3	....	0.3	18.1
	100.0	100.0	100.0	100.0

In this operation three product streams are taken from the Hypersorber. The propane is recovered as a side cut which is essentially ethane-free and contains only about 3 percent butanes and heavier. It is directly usable as L.P.G. without further fractionation. Thus the Hypersorber unit performs the same functions as an absorber, stripper, de-ethanizer and depropanizer in a conventional oil absorption plant. Specifications for

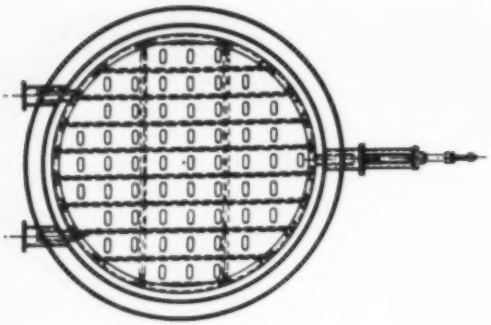
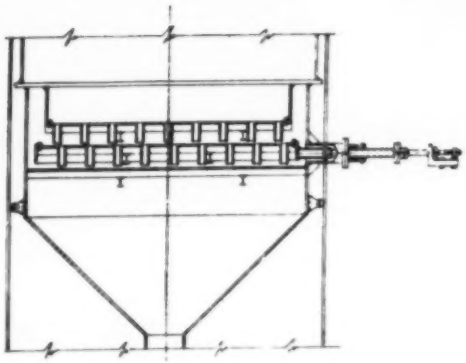


Figure 8. Flow Control Mechanism.



the Hypersorber column for this application are given in Table 7.

TABLE 7

Hypersorber for Propane Recovery from Natural Gas

Feed, MSCF/day	60,000
Operating Pressure, psig	325
Hypersorber Diameter, ft.	10.2
Hypersorber Height, ft.	146
Carbon Charge, lb.	126,000
Carbon Circulation, lb./hr.	225,000

Removal of Nitrogen

Another promising application of the Hypersorption process is the removal of nitrogen from natural gas. A material balance of such a plant is given in Table 8.

TABLE 8

Material Balance
N_2 Removal from Natural Gas

First Hypersorber

	Feed Mol Percent	Overhead Mol Percent	Side Cut Mol Percent	Bottoms Mol Percent
N_2	29.6	33.5		
CH_4	58.6	66.3	.4	
C_2H_6	6.1	0.2	99.1	.5
C_3H_8	4.6		.5	80.2
$C_4H_{10}+$	1.1			19.3

Second Hypersorber

	Feed Mol Percent	Overhead Mol Percent	Bottoms Mol Percent
N_2	33.5	99.0	.8
CH_4	66.3	1.0	98.9
C_2H_6	0.2	....	.3

The natural gas is first processed in a three-product Hypersorber in which an overhead product of methane and nitrogen, a side cut of ethane and a bottoms products of propane and heavier are produced. The overhead of methane and nitrogen is then fractionated in a separate Hypersorber to produce nitrogen as an overhead product and methane as a bottoms product. The ethane from the first Hypersorber is combined with the methane to give the desired nitrogen-free natural gas at a minimum in utility consumption and capital expense.

If a butane-free propane is desired, the first Hypersorber may be designed to produce four products; an overhead of methane and nitrogen, a first side cut of ethane, a second side cut of propane, and a bottoms product of butanes and heavier. This may be accomplished with relatively minor additional expense.

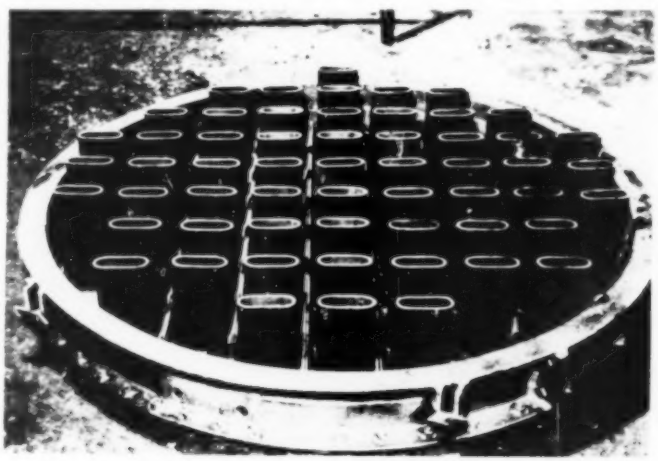
Processing of Refinery Gas Streams

One of the most valuable applications of Hypersorption is in the processing of refinery gas streams for the recovery of propane, ethane and ethylene. An example of such a plant employing ethane cracking to produce propane and high purity ethylene as products is presented in Figure 13. The components of the feed gas and product streams are presented in Table 9.

Important steps in the cycle of operation of this plant are as follows:

a) Recovery of ethylene and heavier components from refinery gas

Figure 9. Shop Photograph of Moving Tray in Feeding Mechanism.



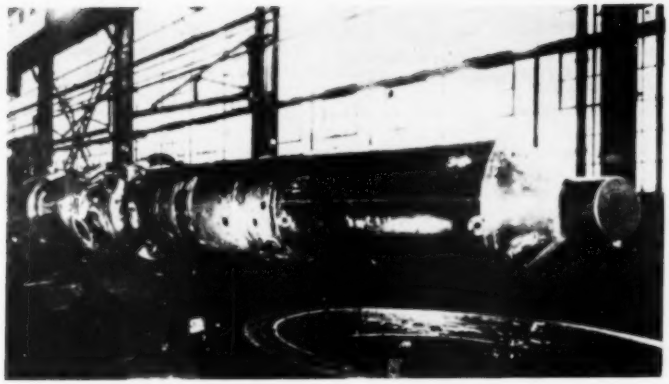


Figure 10. Shop Photograph of Hypersorber Vessel.

TABLE 9

Hypersorption Plant Recovering Ethylene from Refinery Gas Streams with Ethane Cracking

COMP.	Refinery Gas Mol Percent	Hypersorber Feed Mol Percent	Hypersorber Discharge Mol Percent	Hypersorber Make Gas Mol Percent	Hypersorber Sidecut Mol Percent	Ethylene Fract. Overhead Mol Percent
H_2	2.23	11.91	25.40			
CH_4	51.55	35.46	73.92		0.54	1.35
C_2H_4	3.92	13.24	0.35	1.79	39.32	97.11
C_2H_6	22.58	25.18	0.33	3.44	59.84	1.54
C_3H_6	6.18	4.42		29.35	0.16	
C_3H_8	11.94	8.32		54.30	0.14	
C_4H_{10}	1.60	1.47		11.12		

streams and ethane cracker effluent in the Hypersorption unit to produce three product streams consisting essentially of C_1's, C_2's and C_3's respectively.

b) Separation of ethane-ethylene in a small low-temperature column to provide the recycle stream for ethane cracking.

c) Production of the C_3 fraction directly for use as fuel in other chemical processing operations. This fraction can be cracked for a maximum overall production of ethylene if desired.

A more recent development in Hypersorption processing for this type of plant involves replacing the low-temperature fractionator by a second Hypersorption unit, permitting recovery of an ethylene product of high purity, and in addition, recovery of the substantial quantity of hydrogen produced in ethane cracking at over 99 percent purity as a fourth product.

Applications in the Chemical Industry

Hypersorption is applicable to a variety of different gas separations in the chemical industries. These range in pressure level from atmospheric to 800 psi. Some of the more typical applications are as follows:

Purification of Hydrocarbon Synthesis Gas

Separation of carbon dioxide and sulfur compounds, such as hydrogen sulfide and carbonyl sulfide in the feed gas to a Hydrocol or Fischer-Tropsch synthesis unit, is a major problem when utilizing coal or low-grade crudes as a primary fuel.

The application of Hypersorption to this problem is illustrated in Table 10.

TABLE 10

Purification of Hydrocarbon Synthesis Gases

	Feed Mol Percent	Top Product Mol Percent	Bottom Product Mol Percent
H_2	52.5	59.0	...
N_2	4.5	5.1	...
CO	29.1	32.7	...
CH_4	1.0	1.1	0.2
COS	175ppm	2 Grains per 1000 scf.	3.6
H_2S	0.4	...	...
CO_2	12.5	...	96.2

Acetylene Recovery From Oxidation Gases

The recovery of acetylene from the products of partial oxidation of natural gas for the production of acetylene is an operation which requires a high degree of recovery and has definite limitations regarding allowable pressures and temperatures. Hypersorption handles this problem readily, and its application to this type of operation is illustrated in Table 11.

TABLE 11

Acetylene Recovery from Oxidation Gases

	Feed Mol Percent	Top Product Mol Percent	Bottom Product Mol Percent
H_2	48.4	54.4	...
CO	32.3	36.3	...
CH_4	6.0	6.7	0.1
CO_2	4.0	2.5	16.2
C_2H_2	9.2	0.1	82.8
C-+	0.1	...	0.9

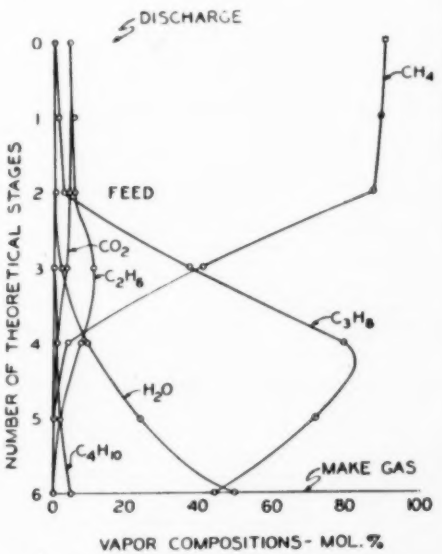


Figure 11. Plot of Stagewise Calculations for Separation of Ethane and Propane.

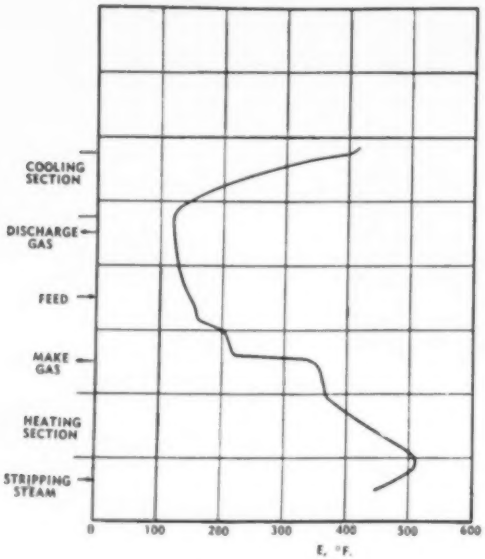


Figure 12. Temperature Gradient in Commercial Hypersorber.

Separation of Methane and Hydrogen Chloride

The separation of methane and hydrogen chloride involves a difficult operation when water or similar solvents are employed. Hypersorption easily effects this separation. Results of a typical operation are illustrated in Table 12.

TABLE 12
Separation of Methane and HCl

	Feed Mol Percent	Top Product Mol Percent	Bottom Product Mol Percent
H_2	7.1	12.6	....
N_2			
CH_4	49.4	87.2	0.3
HCl	43.5	0.2	99.7

TABLE 13
Purification of Hydrogenation Gases

	Feed Mol Percent	Top Product Mol Percent	Bottom Product Mol Percent
H_2	57.9	75.0	
N_2	25.1	25.0	25.4
CH_4	17.0	....	74.6
Argon			

Purification of Hydrogenation Gases

The recovery of hydrogen from purge gas ammonia synthesis operations has normally been considered very difficult. Hypersorption effects this recovery readily and can produce an essentially complete recovery of the valuable hydrogen from this purge gas as illustrated in Table 13.

The application of Hypersorption extends beyond these described above, and includes the separation of hydrogen from a number of contaminats, recovery of ethane from natural gas, and recovery of CO_2 from flue gas. The variety of new gaseous separations now made possible are appreciably extending the field for production of new chemicals and fuels.

REFERENCE

[1] Kehde, H.; Fairfield, R. G.; Frank, J. C.; Zahnstecher, L. W.: Chem. Engr. Prog. **44**, 578-82 (1948).

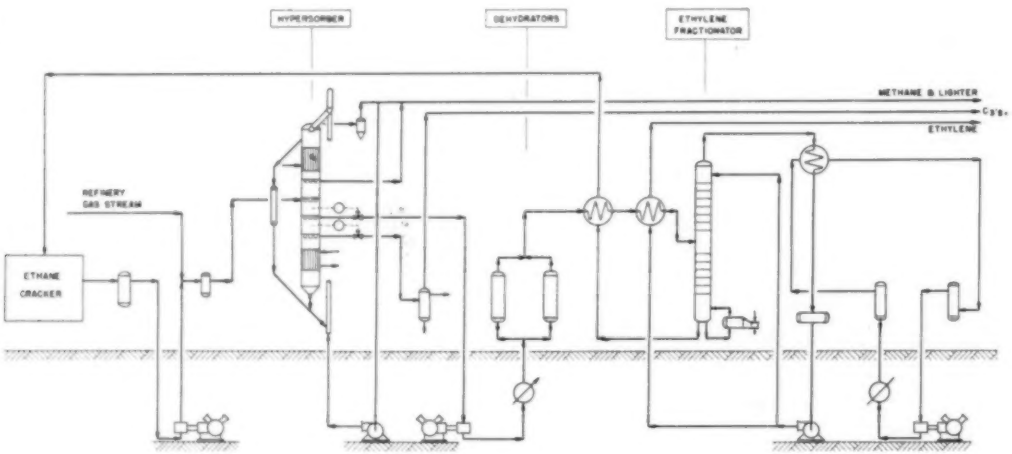


Figure 13. Hypersorption Plant for Recovery of Ethylene from Refinery Gas Streams with Ethane Cracking.

The Design of Square Headers

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HOWEVER OLD the problem of properly designing a square header may be, the endeavor to solve it is one which it is always worthwhile to encourage anew. The fact that the problem is still open, makes in favor of an honest attempt to think it out.

Engineering advantages which attend an effort to solve the problem accrue quite apart from any success to reach the goal. For even when the height we strive to climb be inaccessible, we can still see and understand more than those who never leave the plain.

Construction codes do not give rules for design purpose. They prescribe that the maximum allowable working pressure is to be determined on the basis of a hydrostatic deformation test, which is in reality the safest course—at present.

A thorough investigation of the stress distribution in a square header with solid walls is a cumbersome task. To find mathematical expressions for the stresses in a header which has holes drilled for tubes and hand holes in its sides, is to attempt the impossible. For the individual arrangements of such holes vary widely, and all cases cannot possibly be included in a single formula.

Even for solid wall headers the developed mathematical expressions are so complex that an ordinary designer hesitates to use them. This does not mean that there is lack of interest in the subject. On the contrary, most designers do not accept the stereotyped system; they prefer to investigate—to look for a readily comprehensible and reasonably safe expression which they can use in their every day tasks. The author has endeavored to contribute to that end.

The reader is invited to climb the height along a trail heretofore unmapped. The new view will cast a clearer light upon the old problem; a simple reasonably safe formula, which can be represented by a simple graph, emerges. A critical zone is found to exist beyond which no holes in the sides should project. Other advantageous design fragments, reasonable guesses at the undiscovered, are added to our possessions in the way of knowledge.

However, the author does not profess to have conquered the problem as such.

FOR practical purposes a square header may readily be considered as a polygon inscribed in a cylindrical vessel. The total wall stress at a corner is then equal to the sum of the stress—S_m—produced by the bending moment therein and the stress—S_p—produced by direct tension due to the internal pressure, that is,

$$S = S_m + S_p$$

When a small corner radius is used the flat side portions can be considered as uniformly loaded beams with fixed ends. Thus S_m, in the direction of S_p is,

$$S_m = \frac{p \times l^2}{12} \times \frac{6}{t^2} \times \cos\phi = \frac{p \times l^2}{2 \times t^2} \times \cos\phi$$

in which expression,

p = internal pressure, psi
l = width of flat portion, inches
t = wall thickness, inches
ϕ = angle between forces

S_p again has the known value,

$$S_p = \frac{p \times r}{t} \text{ (See remarks later)}$$

r = radius of cylindrical portion (see Figure 1.)

Thus,

$$S = \frac{p \times l^2}{2 \times t^2} \times \cos\phi + \frac{p \times r}{t}$$

A general form of this equation is,

$$S = \frac{p \times \rho^2 \times r^2}{2 \times t^2} \times \cos\phi + \frac{p \times r}{t}$$

or,

$$S = \frac{p \times r}{t}\left(\frac{\rho^2 \times r}{t} \times \cos\phi + 1\right) \text{(polygon)}$$

when $l = \rho \times r$

It will be seen that the stress due to bending diminishes with smaller values of ρ—which is only natural. When ρ is smaller than .075 this stress can be neglected altogether, that is, the vessel can be treated as cylindrical.

For a square header the factor ρ is equal to 1.414 and $\cos\phi = .707$. The formula for S thus takes the form,

$$S = \frac{p \times r}{t}\left(\frac{r}{t} \times \cos\phi + 1\right)$$

when $\frac{r}{t} = \eta$

$$S = p \times \eta\,(.707 \times \eta + 1)$$

and,

$$p = \frac{S}{\eta(.707 \times \eta + 1)} \text{ psi. (square headers)}$$

This formula can readily be represented by a simple graph. The ratio $\eta = \frac{r}{t}$ is of such a character that any size header can be represented thereby. The given graph in Figure 2 applies to SA-181 Gr. I Material for temperatures up to 650° F. The factor of safety is 5. Similar graphs can readily be worked up for other materials and temperatures.

For pressure rating work—when the physical dimensions are known—this graph can be used as a safe guide. (See remarks on the corner radius later.)

For design purposes again the correct ratio of $\frac{r}{t}$ can be quickly established. However, since r designates the mean radius it is necessary to have a fair estimate of the required thickness. This can be had by considering the bending stress only, that is,

$$t' = l'\sqrt{\frac{p}{2 \times S}}$$

wherein,

l' = inside dimension of header, inches.

Using the value thus found for t' the designer can determine the probable value of r from a full scale layout.

The true value of t is, however,

$$t = \frac{r}{\eta} \text{ (η from graph)}$$

The thus calculated thickness is ordinarily rounded off to the nearest even fraction of an inch. The actually prevailing stress is then determined by using actual dimensions.

The mathematical expression for η, for a specific design case, is

$$\eta = \frac{-.707 + \sqrt{1 + \frac{2.83 \times S}{p}}}{1.414}$$

Square headers with rather sharp corners are ordinarily small in size. The required thickness is chiefly governed by the flat plate portion. For this reason it will be found that t is nearly always greater than 10 percent of r. The Lame' formula should there-

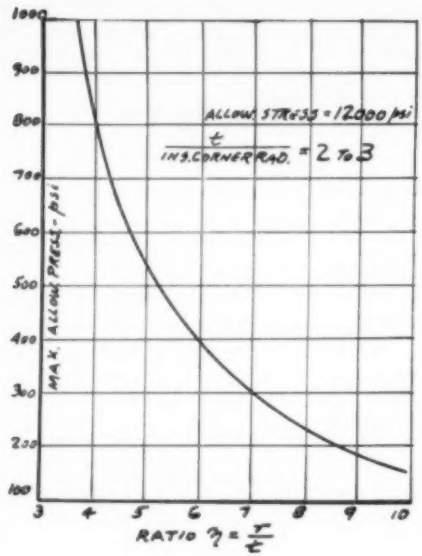

FIGURE 2

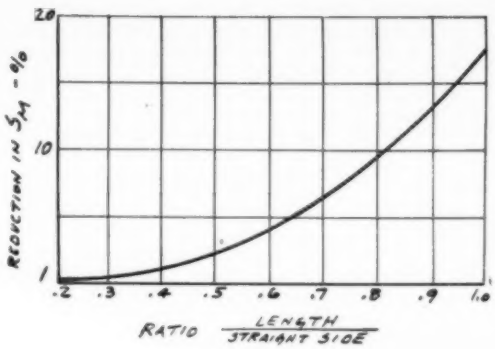

FIGURE 3

fore be used when the internal pressure is higher or when the metal temperature is so high that the material is appreciably weakened thereby.

A recommended practice is to first determine the required thickness as outlined hereinbefore and to use the Lamé formula as an additional "check" on the prevailing stress. The expression for S will then take the form,

$$S = p \times \left[\frac{.707 \times r^2}{t^2} + \frac{K^2 - 1}{K^2 + 1} \right]$$

in which,

$$K = \frac{\text{outside radius}}{\text{inside radius}} = \frac{r + .5 \times t}{r - .5 \times t}$$

r and t as before.

Square headers, having an over-all length between the end plates of less than five times the straight side, are less vulnerable to bending in the straight side. This is due to additional strength derived from the close proximity of the stiff end plates. The S_m stress can therefore be reduced approximately as indicated by the graph in Figure 3.

Drilling of holes in the straight sides tends to invalidate calculations which are based upon the solid wall concept. However, the influence from such drilling is not too serious if due care is exercised in laying it out.

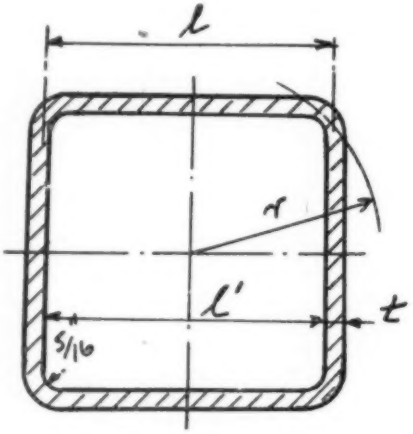

FIGURE 1

The bending moment increases rapidly toward a corner from a distance of $.2113 \times l$ therefrom. Toward the center from this point, the increase is less pronounced. Thus there is a critical zone at a corner into which no hole should be drilled fully or partly. A convenient readily memorizeable expression for the maximum permissible diameter of a hole is,

$$D_{max} < .8 \times l \text{ when } \frac{t}{\text{inside corner radius}} = 2 \text{ to } 3.$$

When this requirement is complied with there is no serious effect from ordinary tube holes being drilled into a straight side. However, if a wedged-in plug is used to close up a hole (as for instance in header boxes) having a diameter slightly greater than D_{max} it becomes necessary to check into the wedging action. In many instances it will be found that stresses of considerable magnitude are thus added. To guard against inherent stresses which cannot be estimated it is a prerequisite that headers of the square shape be fully stress relieved.

SAMPLE CALCULATIONS

Refer to Figure 1.

Header size: 6" square (inside dim.)
Design press.: 300 psi.
Design temp.: < 650° F.
Material: SA-181 Gr. I
S = 12,000 psi.

$$\text{Use } \frac{t}{\text{ins. corner rad.}} = 2 \text{ to } 3.$$

First determine the value of η

$$\eta = \frac{-.707 + \sqrt{1 + \frac{2.83 \times 12{,}000}{300}}}{1.414} = 7.0$$

Then "estimate" the required thickness,

$$t' = 6\sqrt{\frac{3000}{2 \times 12{,}000}} = .66"$$

thus r = 4 7/16" (from layout)

The required thickness t is,

$$t = \frac{4.438}{7} = .63" \text{ (Use 11/16")}$$

and the prevailing stress,

$$S = \frac{300 \times 4.438}{.688} \times \left(\frac{4.438 \times .707}{.688} + 1 \right)$$

S = 10,650 psi.

Also,

$$S = \frac{300 \times 6.25^2}{2 \times .688^2} \times .707 + \frac{300 \times 4.438}{.688}$$

S = 10,750 psi.

Using the Lamé formula,

$$K = \frac{4.814}{4.125} = 1.16$$

$$S = 300 \times \left[\frac{.707 \times 4.438^2}{.688^2} + \frac{1.16^2 + 1}{1.16^2 - 1} \right]$$

S = 10,850 psi.

It will thus be seen that the "estimated" thickness is accurate enough for practical purposes.

Stepwise Expansion Program Keeps Plant On Stream

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Petrol Refining Inc., Texas City, Texas

Furnaces in the toluene plant were numbered, dismantled, and transported to the Petrol Refining Inc.'s refinery at Texas City, Texas. Picture shows construction crew erecting furnaces at new site.

UPON acquisition from War Assets Administration, in September, 1947, of the Houdry fixed-bed catalytic cracking unit at Texas City, Texas, the problem of securing charge stock or converting to a crude topping unit faced the new owners.

Available facilities were a catalytic cracking unit and hydrofluoric alkylation unit. The cracking unit had a capacity of 10,000 to 12,000 barrels of gas oil charge per day. The alkylation unit had a capacity of 1600 barrels of finished alkylate per day. Charge stocks for the units had to be arranged for, and extensive repairs made to the facilities.

After an extensive survey it developed that reduced crude as charge was at such a high price, and demand as fuel oil was so great, that this source of charge stock was considered impractical.

It was then decided to convert the cracking unit to a crude topping unit, temporarily, and later to a combination crude topping and cracking unit operating simultaneously. A study of the facilities indicated that the cracking unit converted to a crude topping unit would have a capacity of approximately 27,000 barrels per day, using only the furnace, charge pumps and distillation sections of the unit. This conversion was made by installation of the necessary lines and valves as shown in Figure 1. Crude topping tests, started December 19, 1947, proved satisfactory. Standard yields of gasoline, kerosine, No. 2 burning oil and topped or reduced crude were produced from crude charged. Inspection tests of products are not included because of space limitation, as operation was conducted on crudes ranging from 24 to 40.2 API gravity.

WHATEVER the economic factors influencing the operation of a specific oil refinery may be, the plant can make a profit only while it is maintained in production. Down time for maintenance or new construction is extremely expensive. Normal overhead costs are high and go right on, or increase, during down periods—no money is coming in unless the plant runs. This article, describing the several steps followed in adapting a war-time fixed-bed gasoil catalytic cracking unit to peace-time operation on whole crude oil, is a notable demonstration of this basic necessity that process plants should be kept in production. The story serves, too, to demonstrate that ingenuity can be made to substitute for process equipment.

The "temporary solution," allowing the plant to operate as a crude topping unit, posed additional problems of meeting specifications on the products from mixed crudes, such as (a) octane and volatility of gasoline, (b) treating of gasoline, (c) treating of kerosine, (d) boiling range of No. 2 burning oils, and (e) installation of desalting equipment. To overcome these deficiencies procedures were decided upon as follows:

(a) Attempt to purchase natural gasoline to help octane and volatility of the gasoline.

(b) Caustic scrub the gasoline through a converted scrubber attached to the stabilizing equipment.

(c) Install temporary caustic scrubber from available equipment for kerosine.

(d) Correction of boiling range of No. 2 burning oil could be accomplished by taking out a cut of naphtha from non-kerosine-producing crudes and blending back into No. 2 burning oil, or by undercutting of gasoline to produce a 365-375 end point. A combination of both operations was then used with proper results.

Topping operations on mixed crudes

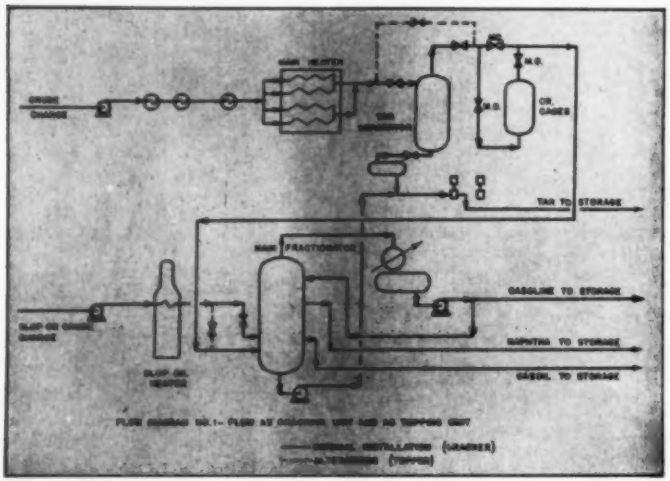


FIGURE 1

for December, 1947, and January and February, 1948, gave yields as follows:

Products	Volume Percent
Gasoline	23.4
No. 2 Burning Oil	36.3
Reduced Crude	39.6
Gas and Loss	0.7
	100.0

(e) Two 10-foot x 30-foot x 1⅛-inch vessels were purchased and installed for desalting residence time, using a chemical emulsion breaking medium.

During the time topping operations were being carried on work was being done on cases, lines, compressors and other equipment which would ultimately be used in the combination topping and cracking operation.

It was deemed advisable to make changes to the Houdry furnace, which was a 4-pass, 80 million-Btu per hour unit, which would allow us to charge two coils with crude and two coils with reduced crude, or on other crudes to charge three coils with crude and one coil with reduced crude.

Furnace, tar separator, synthetic tower and line changes were prepared for installation, and when all fabrication was ready the plant was shut down and all changes were made. Such an operation needed only three of the six cracking cases with which the unit was equipped.

The changes made on the unit were as follows:

(a) Change outlet transfer lines on two passes of furnace and valve them off so they could be used to switch from topping to cracking and back again, without shutting down.

(b) Change outlet transfer lines on two passes of the furnace and valve them off so they could by-pass the tar separator when charging crude.

(c) Install by-pass around tar separator so it would remain idle when full topping operation was conducted or when using gas oil as charge for Houdry heater.

(d) Extend transfer line from furnace to tie into vapor line from cases at a point between the case by-pass block valve and the synthetic tower.

(e) Reroute heat exchanger lines by way of salt settlers and back through quench oil exchangers.

(f) Reroute suction and discharge lines to and from furnace charge pump and tar separator bottoms pump.

(g) Convert one tar separator bottoms pump-out pump to charge pump for reduced crude from synthetic crude tower and rearrange pump-out from synthetic crude tower bottom.

(h) Change furnace firing contacts and fuel supply lines to furnish fuel for different outlet temperatures of crude and reduced crude charges.

(i) Blind off all salt, air, steam and vapor lines to cases not being used in the operation, and reset timing device to operate three cases on cycle instead of six cases as originally installed.

Figure 2 shows major changes, and present flow arrangement, but many small changes, too numerous to show are not included.

The operation is conducted generally, but with variables according to character of crudes, along lines as follows: Raw crude is charged to three of the four furnace coils at an average rate during nine months of 1948 of 16,730 barrels per calendar day. The charge is passed through products heat exchangers to the desalter at a temperature of 230° F. at 50 psi. From the desalters, where 95 to 96 percent of the salt is removed, the crude flows to the charge pump and is pumped through the quench oil heat exchangers to the furnace at 385° to 415° F., and at 350 psi. The oil temperature entering the synthetic crude tower averages 640° F. with synthetic tower pressure of 15 psi. The reduced crude, with a small amount of cracked gas oil from the bottoms of the syntheic crude tower, is picked up by a hot oil pump

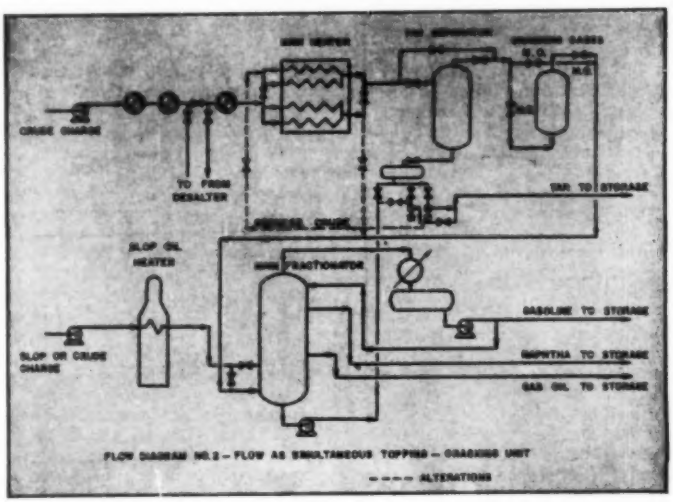
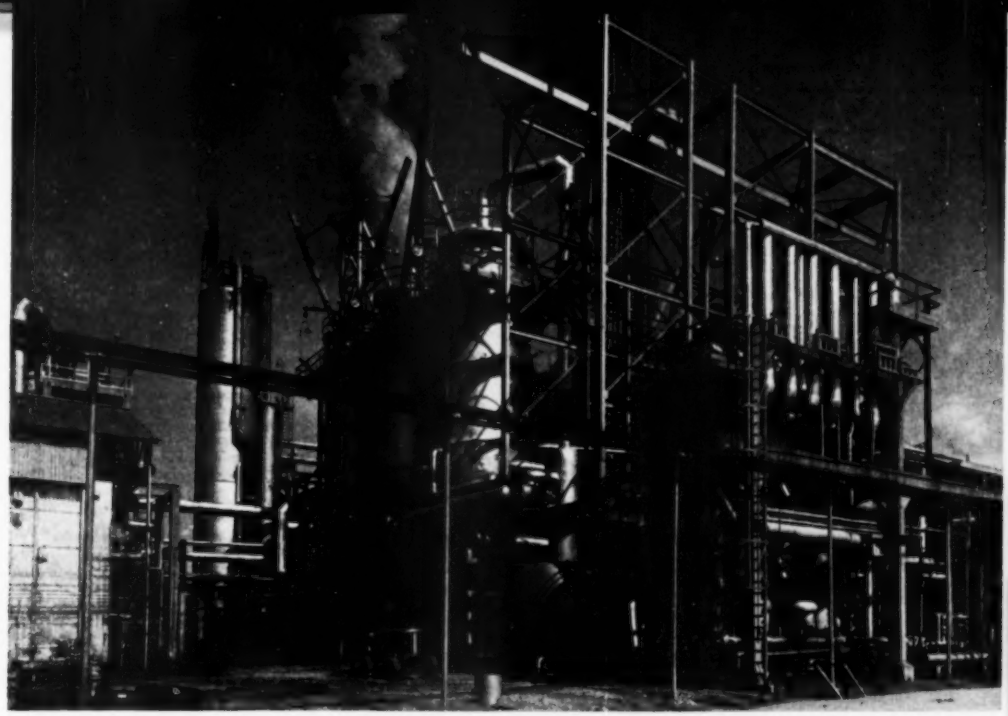


FIGURE 2



Fixed-bed type catalytic cracking unit at Petrol's Texas City plant. Picture shows three of the six cases of the unit, which has a capacity of 10,000 to 12,000 barrels per day of gas oil. The unit was used temporarily as a combination topping and cracking unit during the installation of topping facilities.

formerly used as a pump-out pump for the tar separator, and charged to the one remaining coil of the furnace at 580° F. and 385 psi. at a rate of approximately 7000 barrels per day. The reduced crude is heated to 825° F. and flashed in the tar separator with the aid of about 6 to 7-weight percent saturated steam. Approximately 70 percent of tar separator charge is taken overhead at 820° F. to produce a gas oil case charge with 90 percent recovered at 760° F. from ASTM distillation. The bottoms of the tar separator are pumped to fuel storage. The synthetic crude from the cases enters the synthetic tower along with the heated virgin crude charge.

Charge 100 Percent Crude

	PRODUCTION				
	Volume Percent Propane	Volume Percent Butane	Volume Percent Gasoline	Volume Percent No. 2 Oil	Volume Percent No. 6 Fuel Oil
	0.8	0.2	40.3	33.0	22.2
Gravity			60.2	32.4	18.2
Color			30+	1½	Black
Doctor	Neg.	Neg.	Neg.		
Corrosion	Passes	Passes	Passes	Passes	
Vapor Pressure, Reid	225	84	10.3		
Flash				170	230
Viscosity @ 122° F.				38 @ 100° F.	129
Pour Point					100
Octane No. Clear ASTM			70		
Octane No. 1939 Research			74		
Octane No. 1 cc ASTM			78		
Octane No. 1 cc Research			81.5		

	PRODUCTS				
	Propane	Butane	Gasoline	No. 2 Oil	No. 6 Fuel Oil
Distillation:					
IBP			84	398	382
10 Percent			128	453	640
20 Percent			164	468	686
30 Percent			200	480	702
40 Percent			226	492	Cracking
50 Percent			250	502	
60 Percent			272	514	
70 Percent			294	530	
80 Percent			320	552	
90 Percent			346	578	
E. P.			376	617	
Recovery			97	98	
Residue			1½	2	
Loss			1½	0	

The combining of the streams is effected about twenty-five feet from the entrance to the synthetic tower. The synthetic crude vapors at the point of commingling with fresh crude have a temperature of 840° F., which holds the synthetic tower bottoms to a temperature of 640° F., aided by circulating exchange quench oil. From the synthetic tower are drawn the gases, the combined gasolines, the combined No. 2 burning oils and cracking coil charge stock. An automatic level control device maintains a level in the synthetic tower bottom at all times without affecting the cracking coil charge rate. This is accomplished by taking a slip stream to fuel storage from the bottom of the synthetic crude tower, when necessary.

The combined production yields from the combination simultaneous topping and cracking operation are given in the tables at the left for the month of December, 1948.

These yields were obtained on a throughput of 508,000 barrels of crude oil per month of 12 different grades ranging from 24.7 to 40.0 API gravity domestic crudes and 31.0 to 54.0 API gravity Venezuelan crude.

To have conducted a standard operation of first topping then cracking, the throughput for the month would have been materially decreased, and as the plant was over-supplied with crude it

Equipment and materials for construction of crude topping facilities to handle a million barrels of crude per month was obtained from a wartime toluene plant in the Beaumont, Texas, area. The heaters and columns for the topping units are at the right in the picture. Construction crew is working on foundations for pumping equipment for the units. Catalytic cracking unit is in background.

was necessary to charge as much as could be economically processed.

To have topped 18.5 days at 22,000 barrels per day would have given the six-case Houdry unit enough charge for 10.5 days, allowing two days for changing over from topping to cracking and back to topping again. During the 31-day period we would then have run crude oil 18.5 x 22,000 or 407,000 barrels of fresh crude, and cracked the reduced crude for 10.5 days, thereby reducing the crude charge 100,000 barrels per month. This was not desirable as all the crude charge possible was needed to keep storage available for incoming crude supplies. The final result of all products when blended would have amounted to approximately the same quality as produced by the simultaneous topping and cracking operation.

During the early stages of preparing the units for topping and later simultaneous topping and cracking, it was decided to seek equipment for erection of topping facilities to handle the crude supply of 1 million barrels per month. Such equipment was found to be available from War Assets Administration in a toluene plant formerly operated by Magnolia Petroleum Company at Beaumont, Texas. These facilities were purchased and a contract let for erection of two crude units at Texas City, each capable of handling a charge of 25,000 barrels per day. This construction now is about 60 to 70 percent complete. When the units are ready to operate, the Houdry unit will then be changed back to full operation of 10,000 to 12,000 barrels per day gas oil case charge.

The conventional operation of the topping units and the Houdry unit will be somewhat as follows:

1) Crude will be charged to topping units where gasoline, kerosine and No. 2 oil will be withdrawn to storage for straight run stocks. The gasoline from the crude units will be co-mingled with butane fractions from the Houdry unit during processing to correct boiling range and to conserve butane fractions. This co-mingling will be accomplished by one of two methods, and maybe both will be used: (a) reflux the crude tower, or (b) pump butane into vapor line from crude towers ahead of condensers to get some beneficial cooling effect, and possibly pump butane into gasoline line between condensers and coolers for further beneficial cooling effect.

2) Reduced crude from the bottom of crude towers will be picked up after a cooling coil and charged to the Houdry heater at a rate necessary for handling all reduced crude from units. Provisions will be made to take a slip stream to storage when necessary and a connection to storage will be provided to augment charge to furnace with reduced crude or gas oil when needed for full case charge. In case the Houdry furnace is down for any reason, all reduced crude will be pumped to storage for charging when the Houdry furnace is put back on again. It is possible that we may decide to recycle some No. 2 oil to the Houdry furnace for higher gasoline production, and lower No. 2 oil production.

3) The Houdry unit will operate in a conventional manner, charging reduced crude or gas oil to the furnace to give cases full capacity of ten to twelve thousand barrels per stream day case charge. Production from the Houdry will be propane-propylene, butane-butylene, motor gasoline, No. 2 burning oil and tar separator bottoms. Sale of propane-propylene is to Monsanto Chemical Company by pipe line. Sale of butane-butylene is to neighboring refinery by pipe line. Gasoline will be sold as high-jump octane premium grade gasoline, or blended with straight run for housebrand gasoline. No. 2 burning oil will be blended with straight run No. 2 burning oil, or recycled in the Houdry cases to produce more high-octane gasoline. Tar separator bottoms are sold to another plant for black oil thermal cracking, or viscosity breaking and vacuum distillation to produce catalytic cracking charge stock for their units.

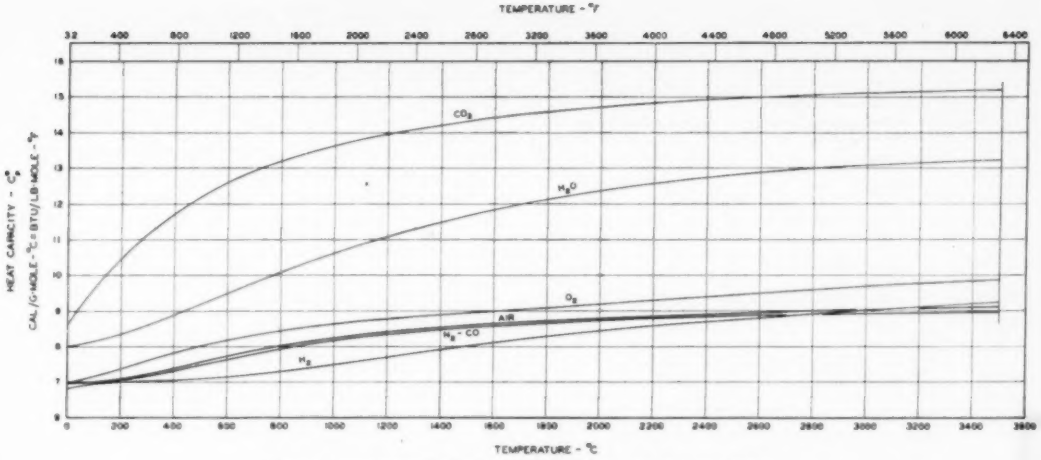


Figure 1. Heat Capacity Curves for N_2, O_2, Air, H_2, CO, CO_2, and H_2O.

Thermochemistry for the Petrochemical Industry

PART VII—THE COMBUSTION GASES

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NO OTHER group of gases has a comparable interest to the engineer, to the scientist or to mankind in general as the combustion gases[1]—nitrogen, oxygen, air, hydrogen, carbon monoxide, carbon dioxide and water vapor (steam). The study of fundamental processes such as oxidation and reduction, hydrogenation and dehydrogenation require basic information on these compounds. In the generation, transmission, and utilization of heat and energy, these compounds are of first importance. One member of the group belongs exclusively to the engineer, not the scientist. This member is air, which is not a compound but a mixture of compounds.

In view of their importance one would expect these substances to be the subject of extensive study, both experimental and theoretical, and this is the case. It may be surprising, however, to find significant changes within the past two or three years in the accepted "best" values of properties such as heat capacity. The history of heat capacity measurements and determinations for this group of compounds is long—and is interesting. Much of the development of modern science, particularly thermodynamics, is revealed in the study of the history of heat capacity determinations of these compounds. The initial systematic investigations of Dulong[7] in 1829, the pioneer accurate calorimetric work of Regnault[49] in the middle 1800's, the development of various methods—velocity of sound, explosion, etc., the accurate modern calorimeters of the National Bureau of Standards, and the development of the spectroscopic method are all revealed in such a study. Much of such historical data are contained in Partington and Shilling, *Specific Heats of Gases*.[48]

IN THE PREVIOUS papers[38, 39, 40, 41, 42, 43] the thermodynamic properties of the principal hydrocarbons have been presented. For this information to be of practical use it is necessary to have reliable thermodynamic data for another group of compounds, usually called the combustion gases. This group, consisting of nitrogen, oxygen, air, hydrogen, carbon monoxide, carbon dioxide and water vapor (steam) is considered here.

Dr. Kobe is professor of chemical engineering at the University of Texas and Mr. Long is Celanese Corporation fellow in chemical engineering there.

The first reliable spectroscopic heat capacities of nitrogen were by Johnston and Davis[19] in 1934. These values were corrected and brought up to date by Wagman, et al.[59] in 1945. The latest values in *Tables of Selected Values of Chemical Thermodynamic Properties*[52] (hereafter referred to simply as NBS Tables) are in agreement with these later values, and they were used to write this paper.

For oxygen, Johnston and Walker[20] made the first reliable spectroscopic calculations in 1933. These were corrected by Wagman et al.[59] in 1945 and used in the API 44 report. The NBS Tables,[51] however, quote values that are

significantly higher. Dr. Rossini of the National Bureau of Standards stated in a personal communication[50] that these values are the result of more recent data and that the API 44 values are being revised accordingly. The data used here are the latest—those from the NBS Tables.

Air, of course, cannot be treated as the other members of this group. The best heat capacities for air are obtained by summing the best values of its constituents. For this, the composition of air was taken as 78.03 percent nitrogen, 20.99 percent oxygen and 0.98 percent argon (all by volume) in agreement with *Gas Tables* by Keenan and Kaye.[35] The molecular weight of air then is 28.970. Keenan and Kaye used for nitrogen and oxygen the data of Wag-

TABLE 1

Reported Heat Capacity Data for the Combustion Gases

Compound	Temperature Range	Method	Workers	Reference
Nitrogen (N_2)	−181 and +20° C.	Calorimetric	Scheel and Heuse	53
	304 to 477° K.	Calorimetric	Eucken and Lude	9
	20 to 370° C.	Calorimetric	Henry	18
	481 and 691° K.	Calorimetric	Eucken and Mucke	10
	0 to 1000° C.	Velocity of Sound	Dixon, Campbell and Parker	6
	400 to 3000° K.	Velocity of Sound	Shilling	56
	50 to 5000° K.	Spectroscopic	Johnston and Davis	19
	0 to 3000° C.	Spectroscopic	Justi	22
	200 to 5000° K.	Spectroscopic	Wagman, Kilpatrick, Taylor, Pitzer and Rossini	59
	600 to 5400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 4000° K.	Compilation	A.P.I. 44 Report	51
	200 to 6400° R.	Compilation	Keenan and Kaye	30
	298 to 5000° K.	Compilation	National Bureau of Standards	52
Oxygen (O_2)	−181 to +20° C.	Calorimetric	Scheel and Heuse	53
	20 to 370° C.	Calorimetric	Henry	18
	302 to 480° K.	Calorimetric	Eucken and Lude	9
	− 30 to +90° C.	Calorimetric	Wacker, Cheney and Scott	58
	10 to 5000° K.	Spectroscopic	Johnston and Walker	20
	0 to 3000° C.	Spectroscopic	Justi	23
	200 to 5000° K.	Spectroscopic	Wagman, Kilpatrick, et al.	59
	600 to 5400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 4000° K.	Compilation	A.P.I. 44 Report	51
	200 to 6400° R.	Compilation	Keenan and Kaye	31
	298 to 5000° K.	Spectroscopic	National Bureau of Standards	52
Air	−181 and +20° C.	Calorimetric	Scheel and Heuse	53
	0 to 220° C.	Calorimetric	Eucken and Lude	9
	86 to 332° C.	Calorimetric	Dailey and Felsing	4
	0 to 1300° C.	Velocity of Sound	Partington and Schilling	48
	600 to 550° R.	Calculated	Heck	17
	0 to 2000° C.	Calculated	Justi	24
	0 to 288° C.	Calculated	Gerhardt, Brunner, Mickley, Sage and Lacey	12
	− 75 to 2750° C.	Calculated	Ellenwood, Kulik and Gay	8
	100 to 6400° R.	Calculated	Keenan and Kaye	29
Hydrogen (H_2)	−181 to +16° C.	Calorimetric	Scheel and Heuse	53
	90 to 290° C.	Calorimetric	Brinkworth	2
	100 to 600° C.	Calorimetric	Eucken and Mucke	10
	0 to 20° C.	Calorimetric	Wohl and Magat	60
	83 to 372° K.	Velocity of Sound	Cornish and Eastman	3
	0 to 208° C.	Spectroscopic	Giauque	13
	250 to 5000° K.	Spectroscopic	Davis and Johnston	5
	0 to 3000° C.	Spectroscopic	Justi	21
	250 to 5000° K.	Spectroscopic	Wagman, Kilpatrick, et al.	59
	600 to 5400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 4000° K.	Compilation	A.P.I. 44 Report	51
	200 to 6400° R.	Compilation	Keenan and Kaye	34
	298 to 5000° K.	Compilation	National Bureau of Standards	52
	280 to 5000° K.	Spectroscopic	Wooley, Scott and Brickwedde	61
Carbon Monoxide CO)	−180 and +18° C.	Calorimetric	Scheel and Heuse	53
	0 to 220° C.	Calorimetric	Eucken and Lude	9
	20° C.	Velocity of Sound	Schweikert	55
	50 to 5000° K.	Spectroscopic	Johnston and Davis	19
	0 to 3000° C.	Spectroscopic	Justi	25
	200 to 5000° K.	Spectroscopic	Wagman, Kilpatrick, et al.	59
	600 to 5400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 4000° K.	Compilation	A.P.I. 44 Report	51
	200 to 5400° R.	Compilation	Keenan and Kaye	35
	250 to 5000° K.	Compilation	National Bureau of Standards	52
Carbon Dioxide (CO_2)	20° C.	Calorimetric	Scheel and Heuse	54
	20° C.	Calorimetric	Fenning and Whitten	11
	20° C.	Velocity of Sound	Dixon, Campbell and Parker	6
	20° C.	Velocity of Sound	Partington and Shilling	47
	300 to 1200° K.	Spectroscopic	Gordon and Barnes	15
	300 to 3500° K.	Spectroscopic	Kassel	28
	300 to 1500° K.	Spectroscopic	Spencer and Justice	57
	0 to 3000° C.	Spectroscopic	Justi	26
	298 to 3500° K.	Spectroscopic	Wagman, Kilpatrick, et al.	59
	600 to 5400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 3500° K.	Compilation	A.P.I. 44 Report	51
	200 to 5400° R.	Compilation	Keenan and Kaye	33
	298 to 5000° K.	Spectroscopic	National Bureau of Standards	52
Water Vapor (H_2O)	280° K.	Calorimetric	Bjerrum	1
	104° C.	Calorimetric	Brinkworth	2
	120 to 200 atm.	Calorimetric	Koch	44
	240 atm.	Calorimetric	Koch	45
	30 to 120 atm.	Calorimetric	Knoblauch and Koch	37
	298 to 1500° K.	Spectroscopic	Gordon	14
	0 to 3000° C.	Spectroscopic	Justi	27
	298 to 3000° K.	Spectroscopic	Wagman, Kilpatrick, et al.	59
	600 to 6400° R.	Compilation	Heck	16
	− 75 to 2750° C.	Compilation	Ellenwood, Kulik and Gay	8
	298 to 3000° K.	Compilation	A.P.I. 44 Report	51
	200 to 5400° R.	Compilation	Keenan and Kaye	32
	298 to 5000° K.	Spectroscopic	National Bureau of Standards	52

TABLE 2

Free Energies of Formation, Heats of Formation and Heats of Combustion of the Combustion Gases at 25° C.[1]

Compound	Molecular Weight	$\Delta G_f°$ cal./g-mole	$\Delta H_f°$ cal./g-mole	$-\Delta H_c°$—cal./g-mole CO_2(g), H_2O (l)	$-\Delta H_c°$—cal./g-mole CO_2(g) H_2O (g)
N_2	28.016	0	0	.....	.....
O_2	32.0000	0	0	.....	.....
Air[2]	28.970	0	0	.....	.....
H_2	2.0156	0	0	68,317	57,798
CO	28.010	− 32,808	− 26,416	67,636	67,636
CO_2	44.010	− 94,260	− 94,052	.....	.....
H_2O	18.0156	− 54,634	− 57,798	10,519	.....

[1] $-\Delta H_c°$ represents the heat evolved at 25° C. and constant pressure in the combustion of the gaseous compounds in gaseous oxygen to form the products indicated with all of the reactants and products in their appropriate standard reference states.

$\Delta H_f°$ and $\Delta G_f°$ represent the changes in the heat content (enthalpy) and free energy, respectively, for the formation of the gaseous compounds from the elements, with all the reactants and products in their appropriate standard reference states.

[2] Composition of air taken as 78.03% N_2, 20.99% O_2, 0.98% A.

TABLE 3

Heat Capacities of Combustion Gases

cal./g-mole · °C.

°C.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
0	6.959	6.989	6.946	6.538	6.960	8.595	8.001
18	6.960	7.007	6.950	6.877	6.963	8.792	8.017
25	6.960	7.017	6.953	6.892	6.965	8.874	8.025
100	6.978	7.141	6.993	6.968	6.994	9.625	8.135
200	7.044	7.365	7.091	6.998	7.086	10.462	8.350
300	7.159	7.607	7.232	7.011	7.232	11.147	8.604
400	7.307	7.832	7.394	7.033	7.404	11.713	8.882
500	7.469	8.019	7.560	7.071	7.578	12.186	9.173
600	7.630	8.175	7.718	7.128	7.745	12.583	9.478
700	7.780	8.304	7.862	7.204	7.895	12.914	9.782
800	7.912	8.413	7.988	7.293	8.026	13.191	10.071
900	8.032	8.507	8.102	7.389	8.139	13.43	10.343
1000	8.138	8.588	8.201	7.489	8.240	13.63	10.601
1100	8.230	8.658	8.288	7.595	8.327	13.80	10.845
1200	8.311	8.723	8.365	7.699	8.401	13.95	11.076
1300	8.379	8.784	8.431	7.788	8.464	14.07	11.287
1400	8.441	8.843	8.491	7.880	8.525	14.2	11.48
1500	8.497	8.901	8.547	7.968	8.572	14.3	11.66
1750	8.612	9.043	8.667	8.206	8.672	14.5	12.04
2000	8.698	9.180	8.763	8.410	8.751	14.7	12.34
2250	8.765	9.314	8.843	8.582	8.811	14.8	12.58
2500	8.820	9.442	8.913	8.734	8.860	14.9	12.8
2750	8.866	9.562	8.974	8.870	8.901	15.0	12.9
3000	8.905	9.672	9.028	8.990	8.936	15.1	13.1
3500	8.964	9.860	9.113	9.232	8.992	15.2	13.2

TABLE 4

Heat Capacities of Combustion Gases

cal./g-mole · °K.

°K.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
273	6.959	6.989	6.946	6.838	6.960	8.595	8.001
291	6.960	7.007	6.950	6.877	6.963	8.792	8.017
298	6.960	7.017	6.953	6.892	6.965	8.874	8.025
300	6.961	7.019	6.954	6.895	6.965	8.894	8.026
400	6.991	7.194	7.014	6.974	7.013	9.871	8.185
500	7.070	7.429	7.125	6.993	7.120	10.662	8.415
600	7.197	7.670	7.274	7.008	7.276	11.311	8.677
700	7.351	7.885	7.440	7.035	7.451	11.850	8.959
800	7.512	8.064	7.603	7.078	7.624	12.300	9.254
900	7.671	8.212	7.758	7.139	7.787	12.678	9.559
1000	7.816	8.335	7.897	7.219	7.932	12.995	9.861
1100	7.947	8.440	8.021	7.310	8.058	13.26	10.145
1200	8.063	8.530	8.131	7.407	8.167	13.49	10.413
1300	8.165	8.608	8.227	7.509	8.265	13.68	10.668
1400	8.253	8.676	8.310	7.615	8.349	13.85	10.909
1500	8.330	8.739	8.383	7.720	8.419	13.99	11.134
1750	8.486	8.888	8.536	7.989	8.561	14.3	11.62
2000	8.602	9.030	8.656	8.195	8.663	14.5	12.01
2250	8.690	9.168	8.755	8.393	8.747	14.7	12.32
2500	8.759	9.302	8.836	8.568	8.808	14.8	12.56
2750	8.816	9.431	8.907	8.723	8.856	14.9	12.8
3000	8.862	9.552	8.969	8.859	8.898	15.0	12.9
3500	8.934	9.763	9.069	9.111	8.963	15.2	13.2
4000	8.989	9.933	9.117	9.342	9.015	15.3	13.3

man, et al.[59] The data used in this paper are the later data of the NBS tables.

The work of Wagman, et al.[59] also corrected the spectroscopic calculations of Davis and Johnston[5] for hydrogen, Johnston and Davis[19] for carbon monoxide, Gordon and Barnes[15] and Kassel[28] for carbon dioxide, and Gordon[14] for water vapor. But as with oxygen, the NBS tables for water vapor represent later calculations. For hydrogen, even the data of the NBS tables have been superseded by the work of Wooley, Scott and Brickwedde,[61] also of the National Bureau of Standards. In all cases the results reported here are based on the latest available data.

The heat capacity work on these compounds is sum-

TABLE 5
Heat Capacities of Combustion Gases
Btu./lb.-mole ° °F.

°F.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
32	6.959	6.989	6.946	6.838	6.960	8.595	8.001
50	6.960	7.004	6.950	6.872	6.963	8.764	8.014
77	6.960	7.017	6.953	6.892	6.965	8.874	8.025
100	6.962	7.035	6.958	6.908	6.967	9.012	8.040
200	6.976	7.129	6.989	6.956	6.991	9.566	8.124
300	7.004	7.246	7.035	6.982	7.033	10.059	8.233
400	7.047	7.376	7.096	6.996	7.092	10.498	8.361
500	7.107	7.512	7.171	7.000	7.170	10.890	8.500
600	7.180	7.644	7.256	7.008	7.258	11.240	8.646
700	7.262	7.771	7.346	7.020	7.354	11.562	8.801
800	7.351	7.885	7.440	7.035	7.451	11.850	8.959
900	7.440	7.988	7.531	7.058	7.548	12.109	9.122
1000	7.530	8.081	7.621	7.087	7.643	12.345	9.288
1100	7.618	8.166	7.707	7.120	7.735	12.559	9.457
1200	7.705	8.241	7.791	7.158	7.821	12.753	9.627
1300	7.788	8.309	7.867	7.201	7.902	12.929	9.795
1400	7.861	8.372	7.940	7.248	7.976	13.087	9.958
1500	7.932	8.429	8.007	7.296	8.045	13.232	10.114
1600	8.000	8.482	8.072	7.337	8.107	13.37	10.266
1700	8.063	8.530	8.131	7.400	8.167	13.49	10.413
1800	8.120	8.574	8.184	7.459	8.223	13.59	10.556
1900	8.173	8.616	8.236	7.319	8.274	13.70	10.696
2000	8.224	8.653	8.282	7.582	8.322	13.80	10.830
2100	8.271	8.690	8.327	7.641	8.365	13.88	10.961
2200	8.313	8.725	8.367	7.700	8.404	13.96	11.086
2300	8.352	8.760	8.405	7.755	8.441	14.03	11.205
2400	8.389	8.794	8.441	7.810	8.474	14.09	11.318
2500	8.424	8.827	8.475	7.865	8.506	14.1	11.43
2600	8.459	8.866	8.522	8.132	8.636	14.4	11.90
3500	8.675	9.140	8.736	8.350	8.731	14.7	12.26
4000	8.753	9.290	8.829	8.553	8.801	14.8	12.54
4500	8.817	9.434	8.909	8.728	8.857	14.9	12.8
5000	8.869	9.567	8.977	8.873	8.903	15.0	12.9
5500	8.911	9.688	9.036	9.013	8.940	15.1	13.1
6000	8.945	9.793	9.084	9.150	8.973	15.2	13.2
6500	8.976	9.898	9.130	9.277	9.002	15.3	13.2

TABLE 6
Heat Capacities of Combustion Gases
Btu./lb.-mole ° °R.

°R.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
492	6.959	6.989	6.946	6.838	6.960	8.595	8.001
500	6.959	6.993	6.947	6.848	6.961	8.643	8.005
520	6.960	7.004	6.950	6.872	6.963	8.764	8.014
537	6.960	7.017	6.953	6.892	6.965	8.874	8.025
600	6.967	7.070	6.969	6.933	6.975	9.241	8.071
700	6.985	7.171	7.004	6.969	7.005	9.771	8.164
800	7.020	7.297	7.058	6.985	7.055	10.241	8.283
900	7.070	7.429	7.123	6.993	7.120	10.662	8.415
1000	7.135	7.566	7.204	6.999	7.205	11.037	8.558
1100	7.210	7.696	7.290	7.011	7.296	11.375	8.708
1200	7.298	7.818	7.384	7.026	7.393	11.680	8.864
1300	7.384	7.928	7.475	7.045	7.490	11.956	9.023
1400	7.475	8.027	7.566	7.069	7.587	12.206	9.188
1500	7.564	8.116	7.654	7.097	7.678	12.433	9.356
1600	7.655	8.197	7.743	7.131	7.770	12.639	9.525
1700	7.735	8.269	7.820	7.172	7.853	12.825	9.695
1800	7.816	8.335	7.897	7.219	7.932	12.995	9.861
1900	7.890	8.395	7.967	7.267	8.004	13.146	10.021
2000	7.960	8.451	8.034	7.319	8.071	13.29	10.176
2100	8.027	8.501	8.097	7.374	8.132	13.42	10.326
2200	8.089	8.548	8.152	7.430	8.190	13.53	10.471
2300	8.143	8.592	8.206	7.486	8.244	13.64	10.613
2400	8.195	8.631	8.255	7.545	8.294	13.74	10.750
2500	8.244	8.669	8.301	7.606	8.340	13.83	10.883
2600	8.288	8.703	8.343	7.665	8.381	13.91	11.011
2700	8.330	8.739	8.383	7.720	8.419	13.99	11.134
2800	8.368	8.773	8.420	7.778	8.454	14.05	11.250
2900	8.403	8.807	8.454	7.836	8.487	14.1	11.36
3000	8.438	8.840	8.488	7.894	8.519	14.2	11.47
3500	8.581	8.999	8.633	8.148	8.644	14.5	11.93
4000	8.683	9.152	8.744	8.372	8.737	14.7	12.28
4500	8.759	9.302	8.836	8.568	8.808	14.8	12.56
5000	8.821	9.444	8.914	8.739	8.861	14.9	12.8
5500	8.872	9.577	8.982	8.878	8.906	15.0	13.0
6000	8.913	9.696	9.039	9.019	8.943	15.1	13.1
6500	8.946	9.803	9.087	9.157	8.975	15.2	13.2
7000	8.977	9.903	9.132	9.285	9.004	15.3	13.3

TABLE 7
Enthalpies of Combustion Gases
cal./g-mole

°C.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	125.3	126.0	125.1	123.4	125.5	156.7	144.2
25	174.0	175.0	173.7	171.6	174.1	217.9	200.3
100	696.5	705.7	696.5	692.6	697.3	912.2	836.1
200	1397.	1431.	1400.	1391.	1401.	1918.	1630.
300	2107.	2180.	2116.	2091.	2117.	3001.	2477.
400	2830.	2952.	2847.	2793.	2848.	4144.	3351.
500	3569.	3745	3595.	3499.	3598.	5340.	4254.
600	4324.	4555.	4359.	4209.	4364.	6579.	5186.
700	5094.	5379.	5138.	4925.	5146.	7835.	6149.
800	5880.	6215.	5932.	5650.	5942.	9161.	7142.
900	6678.	7061.	6737.	6384.	6751.	10493.	8163.
1000	7482.	7916.	7548.	7128.	7570.	11846.	9210.
1100	8308.	8778.	8377.	7882.	8398.	13220.	10283.
1200	9132.	9647.	9209.	8646.	9235.	14610.	11279.
1300	9965.	10523.	10048.	9395.	10078.	16010.	12500.
1400	10810.	11404.	10894.	10164.	10927.	17410.	13640.
1500	11650.	12290.	11750.	10944.	11783.	18840.	14790.
1750	13800.	14530.	13900.	12944.	13940.	22430.	17750.
2000	15970.	16810.	16080.	15060.	16120.	26080.	20800.
2250	18140.	19120.	18280.	17230.	18310.	29780.	23910.
2500	20340.	21470.	20500.	19380.	20520.	33500.	27090.
2750	22560.	23840.	22740.	21570.	22740.	37230.	30290.
3000	24770.	26250.	24990.	23750.	24970.	40990.	33340.
3500	29240.	31130.	29520.	28380.	29450.	48570.	40130.

TABLE 8
Enthalpies of Combustion Gases
cal./g-mole

°K.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
273	0.0	0.0	0.0	0.0	0.0	0.0	0.0
291	125.3	126.0	125.1	123.4	125.5	156.7	144.2
298	174.0	175.0	173.7	171.6	174.1	217.9	200.3
300	187.9	189.0	187.6	182.5	188.0	235.7	216.4
400	883.2	896.9	883.6	873.6	884.2	1172.	1024.
500	1588.	1628.	1592.	1575.	1590.	2200.	1853.
600	2301.	2383.	2312.	2275.	2310.	3360.	2707.
700	3024.	3161.	3044.	2978.	3047.	4559.	3589.
800	3766.	3959.	3795.	3684.	3800.	5667.	4499.
900	4532.	4773.	4569.	4394.	4871.	6916.	5440.
1000	5299.	5601.	5346.	5112.	5357.	8200.	6411.
1100	6088.	6439.	6142.	5838.	6157.	9513.	7412.
1200	6888.	7288.	6950.	6575.	6966.	10852.	8440.
1300	7700.	8145.	7768.	7320.	7790.	12211.	9494.
1400	8518.	9000.	8593.	8076.	8621.	13590.	10573.
1500	9356.	9880.	9434.	8842.	9459.	14980.	11675.
1750	11458.	12083.	11550.	10821.	11582.	18510.	14520.
2000	13600.	14320.	13700.	12830.	13740.	22100.	17480.
2250	15770.	16600.	15880.	14900.	15910.	25750.	20520.
2500	17940.	18910.	18080.	17020.	18110.	29440.	23630.
2750	20140.	21250.	20300.	19190.	20320.	33150.	26790.
3000	22350.	23620.	22530.	21380.	22530.	36890.	30000.
3500	26800.	28450.	27040.	25820.	27000.	44430.	36520.
4000	31280.	33380.	31590.	30480.	31500.	52050.	43120.

TABLE 9
Enthalpies of Combustion Gases
Btu./lb.-mole

°F.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	194.9	195.9	194.6	191.9	194.9	243.1	224.2
77	312.2	315.1	312.7	308.9	313.3	392.2	360.5
100	473.3	479.7	472.7	467.6	473.5	597.9	545.3
200	1170.	1195.	1170.	1160.	1171.	1527.	1355.
300	1868.	1903.	1870.	1861.	1872.	2509.	2171.
400	2570.	2634.	2576.	2560.	2578.	3537.	3001.
500	3277.	3379.	3289.	3258.	3292.	4607.	3842.
600	3991.	4137.	4010.	3940.	4013.	5714.	4700.
700	4713.	4908.	4740.	4653.	4744.	6855.	5572.
800	5443.	5690.	5479.	5350.	5484.	8026.	6460.
900	6182.	6484.	6227.	6058.	6234.	9224.	7364.
1000	6929.	7288.	6984.	6771.	6993.	10447.	8284.
1100	7686.	8100.	7750.	7468.	7762.	11692.	9222.
1200	8452.	8921.	8524.	8181.	8540.	12960.	10176.
1300	9227.	9748.	9308.	8892.	9326.	14240.	11147.
1400	10009.	10582.	10098.	9620.	10120.	15540.	12130.
1500	10799.	11422.	10895.	10352.	10921.	16860.	13140.
1600	11600.	12270.	11703.	11072.	11729.	18190.	14160.
1700	12400.	13120.	12510.	11799.	12540.	19530.	15190.
1800	13210.	13970.	13330.	12520.	13360.	20890.	16240.
1900	14020.	14830.	14150.	13250.	14190.	22250.	17300.
2000	14840.	15700.	14970.	14000.	15020.	23630.	18380.
2100	15670.	16580.	15800.	14760.	15850.	25010.	19470.
2200	16490.	17430.	16640.	15570.	16690.	26400.	20570.
2300	17340.	18310.	17480.	16360.	17530.	27800.	21690.
2400	18180.	19190.	18320.	17140.	18380.	29210.	22810.
2500	19020.	20070.	19170.	17940.	19230.	30620.	23950.
3000	23280.	24520.	23460.	21880.	23520.	37750.	29780.
3500	27000.	29050.	27810.	26020.	27860.	45020.	35820.
4000	31950.	33960.	32190.	30290.	32240.	52400.	42020.
4500	36340.	38340.	36820.	34560.	36960.	59820.	48340.
5000	40760.	43100.	41090.	39010.	41100.	67300.	54770.
5500	45210.	47910.	45590.	43480.	45560.	74820.	61270.
6000	49670.	52780.	50120.	48010.	50040.	82400.	67840.
6500	54150.	57700.	54680.	52630.	54530.	90020.	74440.

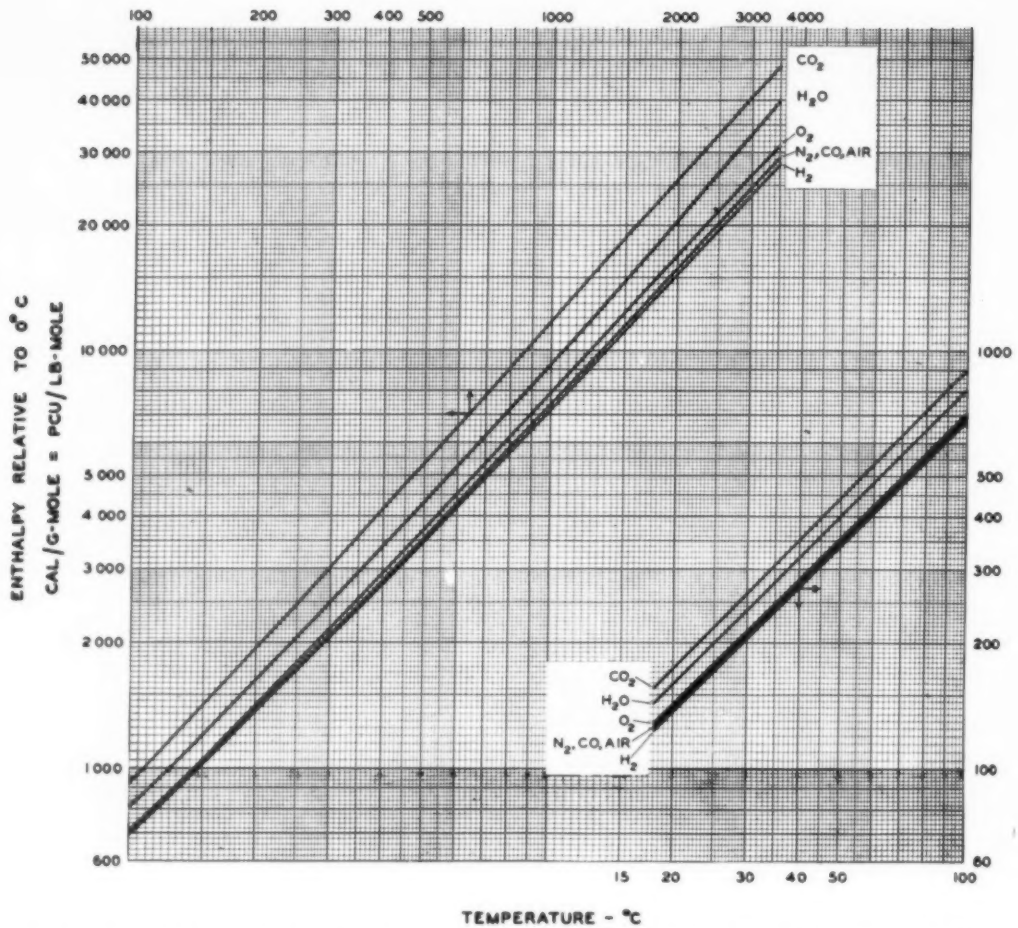

Figure 2. Relative Enthalpies for N_2, O_2, Air, H_2 CO, CO_2, and H_2O. (Multiply readings in Pcu./lb.-mole by 1.8 to obtain Btu./lb.-mole.)

TABLE 11
Mean Heat Capacities of Combustion Gases
cal./g-mole ° °C.

°C.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
0	6.959	6.989	6.946	6.838	6.960	8.595	8.001
18	6.960	6.998	6.949	6.838	6.961	8.706	8.009
25	6.960	7.002	6.949	6.864	6.962	8.716	8.012
100	6.965	7.037	6.965	6.926	6.973	9.122	8.061
200	6.985	7.154	7.001	6.955	7.050	9.590	8.150
300	7.023	7.265	7.054	6.967	7.057	10.003	8.256
400	7.075	7.380	7.118	6.983	7.120	10.360	8.377
500	7.138	7.489	7.190	6.998	7.196	10.680	8.507
600	7.207	7.591	7.266	7.015	7.273	10.965	8.644
700	7.277	7.684	7.340	7.036	7.351	11.221	8.785
800	7.350	7.768	7.414	7.062	7.428	11.451	8.928
900	7.420	7.845	7.485	7.093	7.501	11.66	9.070
1000	7.482	7.916	7.549	7.128	7.570	11.85	9.210
1100	7.551	7.980	7.616	7.165	7.635	12.02	9.348
1200	7.510	8.039	7.674	7.205	7.688	12.17	9.482
1300	7.665	8.094	7.729	7.227	7.752	12.32	9.613
1400	7.718	8.146	7.781	7.260	7.805	12.44	9.740
1500	7.769	8.192	7.830	7.296	7.855	12.56	9.86
1750	7.886	8.304	7.945	7.397	7.965	12.82	10.15
2000	7.983	8.405	8.042	7.530	8.059	13.04	10.40
2250	8.064	8.498	8.125	7.658	8.139	13.23	10.63
2500	8.137	8.586	8.200	7.752	8.209	13.40	10.83
2750	8.202	8.669	8.268	7.844	8.270	13.54	11.02
3000	8.258	8.750	8.329	7.917	8.324	13.66	11.18
3500	8.355	8.895	8.435	8.109	8.415	13.87	11.47

marized briefly in Table 1. Because the sources are so numerous, Table 1 shows only selected work since about 1912. It should be noted that Table 1 lists four important compilations of data. These are Heck,[16,17] Ellenwood, Kulik and Gay,[9] the API 44 report[51] and the *Gas Tables* of Keenan and Kaye. The data of Heck and of Ellenwood, Kulik and Gay are based on the earliest spectroscopic calculations. The API 44 report and Keenan and Kaye have used the data of Wagman, et al.[59]

Table 2 presents data from the NBS tables for molecular weight, free energy and heat of formation, and heat of combustion for each compound. In Tables 3, 4, 5 and 6 are tabulated heat capacities on each of the four temperature scales from the ice point to the approximate equivalent of 4000° K. A graphical presentation of the heat capacity is made in Figure 1.

Tables 7, 8, 9 and 10, tables of enthalpy on all four temperature scales, represent integrations of the actual heat capacity-temperature relations. The enthalpies on the Centigrade and Fahrenheit scales have also been calculated as mean heat capacities, relative to the ice point, and are

TABLE 10

Enthalpies of Combustion Gases

Btu./lb.-mole

°R.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
492	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	55.67	55.93	55.87	54.74	55.68	68.95	64.02
520	194.9	195.9	194.6	191.9	194.9	243.1	224.2
537	313.2	315.1	312.7	308.9	313.3	392.2	360.5
600	751.9	758.8	751.2	744.4	752.4	963.0	867.5
700	1450.	1471.	1450.	1433.	1451.	1914.	1679.
800	2150.	2194.	2153.	2122.	2154.	2915.	2501.
900	2852.	2931.	2861.	2825.	2863.	3961.	3336.
1000	3565.	3680.	3579.	3511.	3580.	5046.	4184.
1100	4285.	4443.	4306.	4210.	4304.	6167.	5047.
1200	5005.	5219.	5035.	4917.	5038.	7320.	5925.
1300	5741.	6007.	5780.	5630.	5783.	8502.	6819.
1400	6493.	6804.	6540.	6369.	6536.	9710.	7730.
1500	7231.	7612.	7289.	7099.	7299.	10942.	8657.
1600	8004.	8427.	8068.	7789.	8072.	12200.	9602.
1700	8774.	9251.	8847.	8499.	8853.	13470.	10562.
1800	9539.	10081.	9623.	9219.	9643.	14760.	11540.
1900	10335.	10918.	10425.	9942.	10440.	16070.	12530.
2000	11127.	11760.	11224.	10689.	11243.	17390.	13550.
2100	11927.	12610.	12030.	11415.	12050.	18730.	14570.
2200	12730.	13460.	12840.	12160.	12870.	20070.	15610.
2300	13540.	14320.	13660.	12890.	13690.	21430.	16660.
2400	14350.	15180.	14480.	13650.	14520.	22800.	17730.
2500	15170.	16040.	15300.	14400.	15350.	24180.	18810.
2600	16010.	16910.	16140.	15180.	16190.	25570.	19910.
2700	16840.	17790.	16980.	15910.	17030.	26960.	21020.
2800	17680.	18660.	17820.	16680.	17870.	28370.	22130.
2900	18510.	19540.	18660.	17470.	18720.	29770.	23270.
3000	19360.	20420.	19510.	18420.	19570.	31170.	24410.
3500	23620.	24880.	23800.	22180.	23860.	38320.	30260.
4000	27950.	29420.	28150.	26370.	28210.	45610.	36320.
4500	32300.	34030.	32540.	30940.	32590.	52990.	42580.
5000	36700.	38720.	36980.	34930.	37010.	60430.	48880.
5500	41120.	43480.	41450.	39360.	41450.	67900.	55290.
6000	45560.	48300.	45960.	43840.	45920.	75420.	61790.
6500	50030.	53170.	50490.	48380.	50400.	83000.	68370.
7000	54510.	58100.	55040.	53000.	54890.	90620.	74970.

TABLE 12

Mean Heat Capacities of Combustion Gases

Btu./lb.-mole · °F.

°F.	N_2	O_2	Air	H_2	CO	CO_2	H_2O
32	6.959	6.989	6.946	6.838	6.960	8.595	8.001
60	6.960	6.996	6.948	6.855	6.961	8.682	8.008
77	6.960	7.002	6.949	6.864	6.962	8.715	8.012
100	6.961	7.010	6.952	6.876	6.964	8.793	8.019
200	6.964	7.052	6.963	6.921	6.972	9.091	8.055
300	6.970	7.102	6.978	6.976	6.987	9.362	8.101
400	6.984	7.159	7.001	6.942	7.007	9.612	8.154
500	7.002	7.220	7.028	6.961	7.033	9.844	8.210
600	7.026	7.283	7.060	6.964	7.065	10.060	8.274
700	7.055	7.347	7.096	6.978	7.101	10.262	8.341
800	7.087	7.409	7.134	6.981	7.140	10.450	8.411
900	7.122	7.470	7.174	6.984	7.182	10.626	8.484
1000	7.158	7.529	7.214	6.989	7.224	10.792	8.558
1100	7.197	7.584	7.256	6.993	7.268	10.948	8.634
1200	7.236	7.637	7.298	7.004	7.312	11.094	8.712
1300	7.277	7.688	7.341	7.013	7.355	11.232	8.790
1400	7.317	7.736	7.382	7.032	7.398	11.362	8.870
1500	7.356	7.781	7.422	7.054	7.439	11.484	8.950
1600	7.395	7.824	7.461	7.061	7.480	11.60	9.029
1700	7.433	7.865	7.500	7.073	7.519	11.71	9.107
1800	7.471	7.904	7.537	7.081	7.558	11.81	9.185
1900	7.507	7.941	7.573	7.093	7.595	11.91	9.263
2000	7.542	7.976	7.608	7.114	7.631	12.01	9.339
2100	7.575	8.010	7.641	7.146	7.665	12.10	9.414
2200	7.607	8.042	7.672	7.180	7.698	12.18	9.488
2300	7.645	8.073	7.709	7.214	7.739	12.26	9.561
2400	7.675	8.102	7.738	7.239	7.761	12.34	9.633
2500	7.707	8.131	7.769	7.269	7.790	12.41	9.70
3000	7.843	7.262	7.903	7.372	7.923	12.72	10.04
3500	7.959	8.377	8.017	7.503	8.033	12.98	10.33
4000	8.051	8.483	8.112	7.631	8.125	13.20	10.59
4500	8.133	8.581	8.196	7.735	8.204	13.39	10.82
5000	8.204	8.674	8.271	7.852	8.272	13.55	11.02
5500	8.267	8.761	8.338	7.952	8.332	13.68	11.21
6000	8.322	8.843	8.399	8.045	8.384	13.81	11.37
6500	8.371	8.921	8.453	8.137	8.431	13.92	11.51

reported in Tables 11 and 12. A double logarithmic plot of enthalpy and temperature is made in Figure 2.

For engineering use, two sets of heat capacity equations have been calculated. Table 13 contains accurate cubic equations to be used to the equivalent of 1500° C. Tables 14 and 15 list equations that may be used up to the equivalent of 3500° C. For all of the compounds, except carbon dioxide, a quadratic equation over this long range is almost as effective as a cubic equation. Simple quadratics therefore, have been used for all except carbon dioxide. Neither the simple quadratic nor the cubic equation is effective for carbon dioxide over this range of temperatures. The most suitable equation was found to be that using the reciprocal of the square root of the temperature. These equations, derived by a modified least squares method, are listed in Table 15. Figure 3 shows typical error curves for some of these equations.

It should be remembered in using these equations that

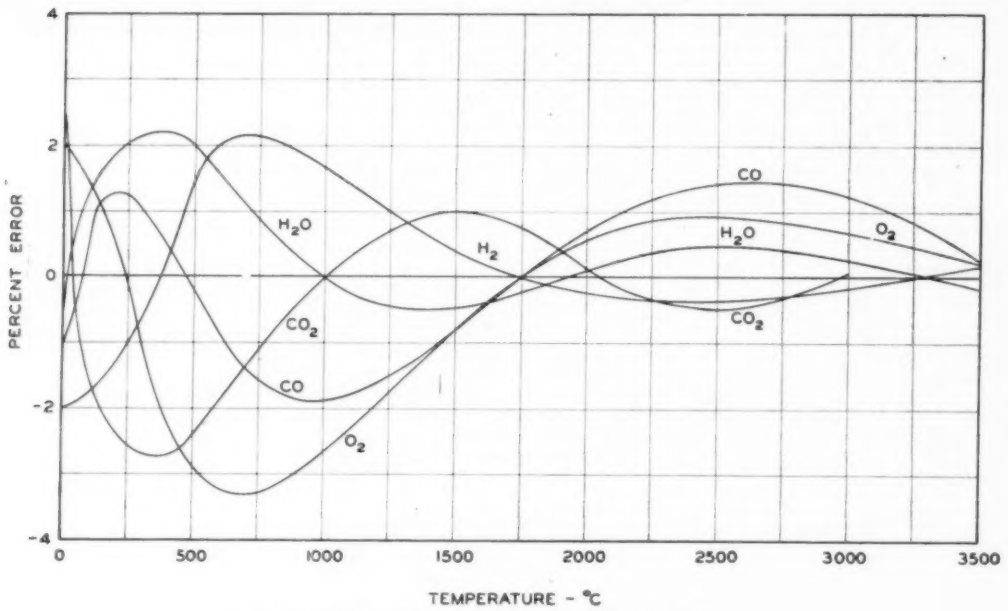

Figure 3. Typical Percent Error Curves for the Equations of Tables 13 and 14.

TABLE 13

Heat Capacity Equations of the Combustion Gases

Range: The equivalent of 0 to 1500° C. on all scales
Equation: $C_p^\circ = a + b(t) + c(t^2) + d(t^3)$.
Units: cal./g-mole • °C. or °K.
Btu./lb.-mole • °F. or °R.

Compound	T	a	b · 10³	c · 10⁷	d · 10¹⁰	ERROR Max. %	ERROR Avg. %
Nitrogen (N_2)	°C.	6.831	5.256	12.68	—6.861	0.30	0.24
	°K.	6.903	—3.733	19.30	—6.861		
	°F.	6.922	2.646	4.335	—1.176		
	°R.	6.903	—2.085	5.958	—1.176		
Oxygen (O_2)	°C.	6.955	27.68	—14.52	3.133	1.19	0.28
	°K.	6.085	36.31	—17.09	3.133		
	°F.	8.906	15.66	— 4.534	0.5372		
	°R.	6.085	20.17	— 5.275	0.5372		
Air (78.03% N_2, 20.99% O_2, 0.98% A by Volume)	°C.	6.917	9.911	7.627	—4.606	0.72	0.33
	°K.	6.713	4.697	11.47	—4.606		
	°F.	6.800	2.884	2.429	—0.8652		
	°R.	6.713	2.609	3.540	—0.8652		
Hydrogen (H_2)	°C.	6.894	0.1800	7.860	—2.079	1.01	0.26
	°K.	6.952	—4.576	9.563	—2.079		
	°F.	6.894	—0.05336	2.480	—0.3565		
	°R.	6.952	—2.542	2.951	—0.3565		
Carbon Monoxide (CO)	°C.	6.921	9.876	8.580	—5.307	0.99	0.37
	°K.	6.726	4.001	12.83	—5.307		
	°F.	6.903	5.287	2.705	—0.9100		
	°R.	6.726	2.223	3.960	—0.9100		
Carbon Dioxide (CO_2)	°C.	8.630	101.16	—69.00	17.84	0.67	0.22
	°K.	5.316	142.85	—83.62	17.84		
	°F.	8.448	57.87	—21.39	3.059		
	°R.	5.316	79.36	—25.81	3.059		
Water Vapor (H_2O)	°C.	7.896	16.44	18.18	—8.587	0.53	0.24
	°K.	7.700	4.304	25.21	—8.587		
	°F.	7.968	3.173	5.750	—1.472		
	°R.	7.700	2.552	7.781	—1.472		

TABLE 14

Heat Capacity Equations of the Combustion Gases

Range: The equivalent of 0 to 3500° C. on all scales
Equation: $C_p^\circ = a + b(t) + c(t^2)$
Units: cal./g-mole • °C. or °K.
Btu./lb.-mole • °F. or °R.

Compound	T	a	b · 10³	c · 10⁷	ERROR Max. %	ERROR Avg. %
Nitrogen (N_2)	°C.	6.910	1.765	—2.271	2.05	0.72
	°K.	6.529	1.488	—2.271		
	°F.	6.895	0.7624	—0.7009		
	°R.	6.529	0.8299	—0.7009		
Oxygen (O_2)	°C.	7.129	1.407	—1.791	3.24	1.20
	°K.	6.732	1.505	—1.791		
	°F.	7.104	0.7851	—0.5528		
	°R.	6.732	0.8360	—0.5528		
Air	°C.	6.944	1.360	—2.148	1.64	0.70
	°K.	6.557	1.477	—2.148		
	°F.	6.920	0.7597	—0.6630		
	°R.	6.557	0.8207	—0.6630		
Hydrogen (H_2)	°C.	6.702	0.9960	—0.7804	2.14	0.79
	°K.	6.424	1.039	—0.7804		
	°F.	6.685	0.5548	—0.2409		
	°R.	6.424	0.5770	—0.2409		
Carbon Monoxide (CO)	°C.	6.980	1.436	—2.387	1.86	1.01
	°K.	6.480	1.566	—2.387		
	°F.	6.865	0.8024	—0.7367		
	°R.	6.480	0.8702	—0.7367		
Water Vapor (H_2O)	°C.	7.880	3.200	—4.833	2.03	0.66
	°K.	6.970	3.464	—4.833		
	°F.	7.824	1.787	—1.492		
	°R.	6.970	1.924	—1.492		

TABLE 15

Heat Capacity Equations for Carbon Dioxide

Range: The equivalent of 0 to 3500° C. on all scales
Error: Max. = 2.65%; Avg. = 0.54%.
Units: cal./g-mole • °C. or °K.
Btu./lb.-mole • °F. or °R.

Temperature Scale	Equation
°C.	$C_p^\circ = 18.036 - 0.00004474(t + 273) - 158.08(t + 273)^{-1/2}$
°K.	$C_p^\circ = 18.036 - 0.00004474(t) - 158.08(t)^{-1/2}$
°F.	$C_p^\circ = 18.036 - 0.0000248\,5(t + 460) - 212.08(t + 460)^{-1/2}$
°R.	$C_p^\circ = 18.036 - 0.0000248\,5(t) - 212.08(t)^{-1/2}$

for a mixture the resulting equation is invariably better than the worst equation used. It can never be worse. They are the same only when the percent error curves are identical.

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Rich Oil Stabilization

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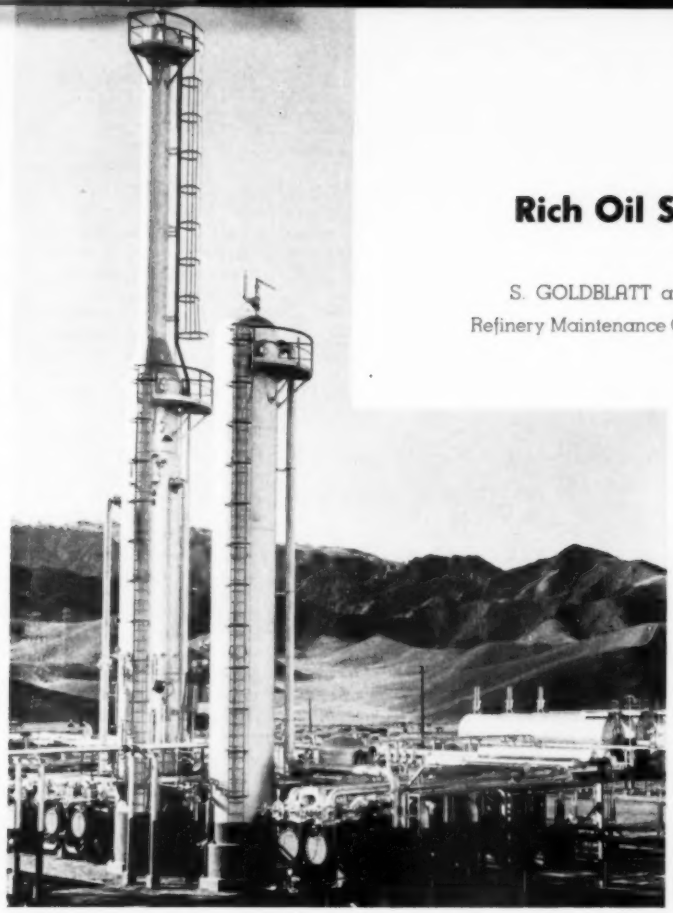


This picture taken at a California plant shows the primary absorber on the right and the rich oil stabilizer on the left.

THE recent interest in the use of rich or fat oil stabilization in gasoline recovery plants[1,2,3] is well justified, as this operation has been found in many instances to be the most economical solution in the design of new plants and in the revamping of existing plants for higher propane recoveries.

Rich oil stabilization refers to the removal of methane and ethane from rich oil while retaining the propane and heavier hydrocarbons. Figure 1 shows two plants, one with and one without rich oil stabilization. A comparison of these plants shows some of the advantages of rich oil stabilization, such as total condensation of the stripping still overhead product, thus eliminating all flashing, recycling, and reabsorption operations.

In any gasoline absorption plant, a major design problem is the separation of methane and ethane from the propane and heavier hydrocarbons contained in the rich oil from the primary absorption operation. The higher the propane recovery, the more difficult this problem becomes, as more methane and ethane will be absorbed with the additional propane.

Although there have been a number of systems described in the past few years for rich oil stabilization, two have been more generally accepted. The first of these,[1] shown in Figure 2, uses absorption for retention of the propane and heavier hydrocarbons, and reboiling for the elimination of methane and ethane. The second, shown in Figure 3, likewise uses absorption for retention of the propane and heavier materials but differs from the first in that a preheater is used to heat the rich oil before it enters the stripping section and stripping is accomplished with the use of recycled vapors or wet gas in place of reboiling.

Recently, a third system, shown in Figures 4 and 5 having certain advantages over previous systems, was put into operation. This third stabilization method, developed by Refinery Maintenance Company, and first used commercially in 1947, utilizes absorption for the retention of the propane and heavier hydrocarbons, a preheater for heating the rich oil prior to its entrance into the stripping section, and reboiling for the elimination of methane and ethane.

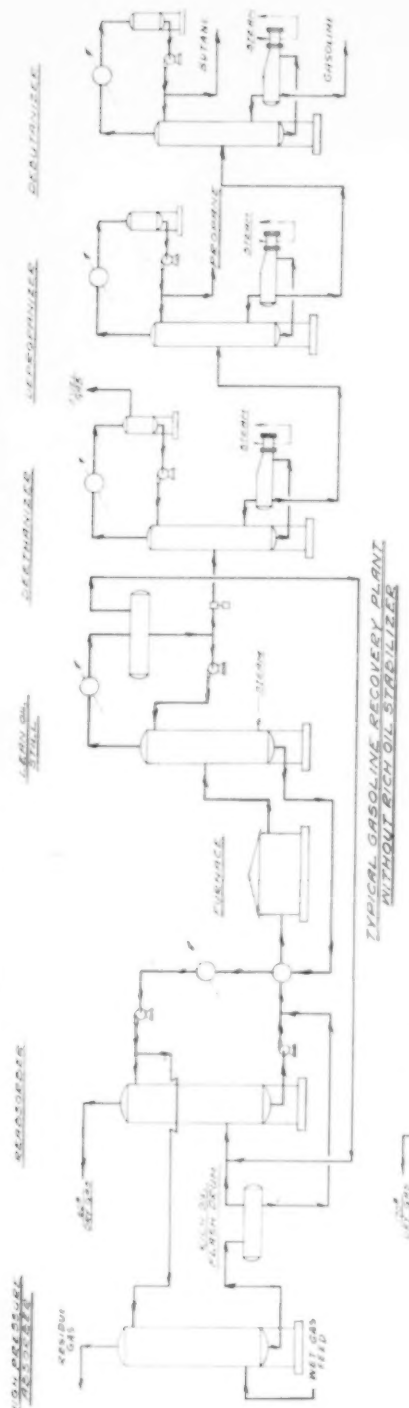
An examination of the two flow sheets of Figure 1 shows that in the plant without rich oil stabilization, vapors are produced in a rich oil flashing operation and in the stripping still reflux drum which must be recycled and reprocessed in the reabsorber in order to prevent excessive loss of propane, butane, and gasoline that were recovered in the initial absorption. Methane and ethane are only partially separated from the heavier hydrocar-

RICH OIL stabilization—separation of methane and ethane from the rich oil with retention of the propane and heavier hydrocarbons—is one of the major problems in the design of gasoline plants. Stabilization becomes more difficult the higher the propane extraction percentage.

This article compares two gasoline plants, one with rich oil stabilization and one without, and points out the advantages of the operation. Of extreme interest to process design engineers and operators are the discussions presented on two systems generally used in the gas-gasoline industry.

A new system, possessing several advantages over previous systems, is presented also. This system includes absorption to retain the propane and heavier components, preheated rich oil for charging to the stripping section, and elimination of methane and ethane by reboiling.

Mr. Goldblatt is process engineer and Mr. Nelly is vice president of Refinery Maintenance Company.



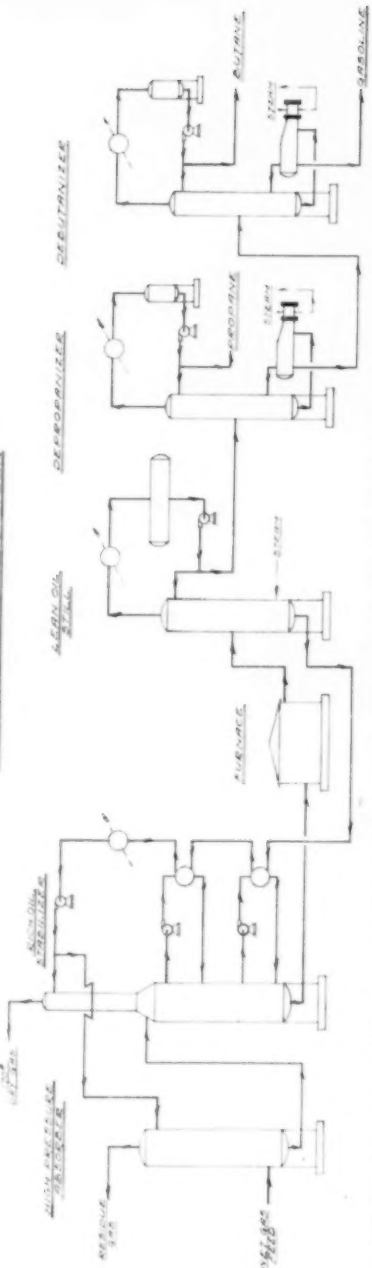


Figure 1. Gasoline Recovery Plant with Preheater-Reboiler Rich Oil Stabilizer.

bons in the single flash at the still reflux drum; so a deethanizer column in the fractionating section of the plant is necessary to produce commercially pure propane.

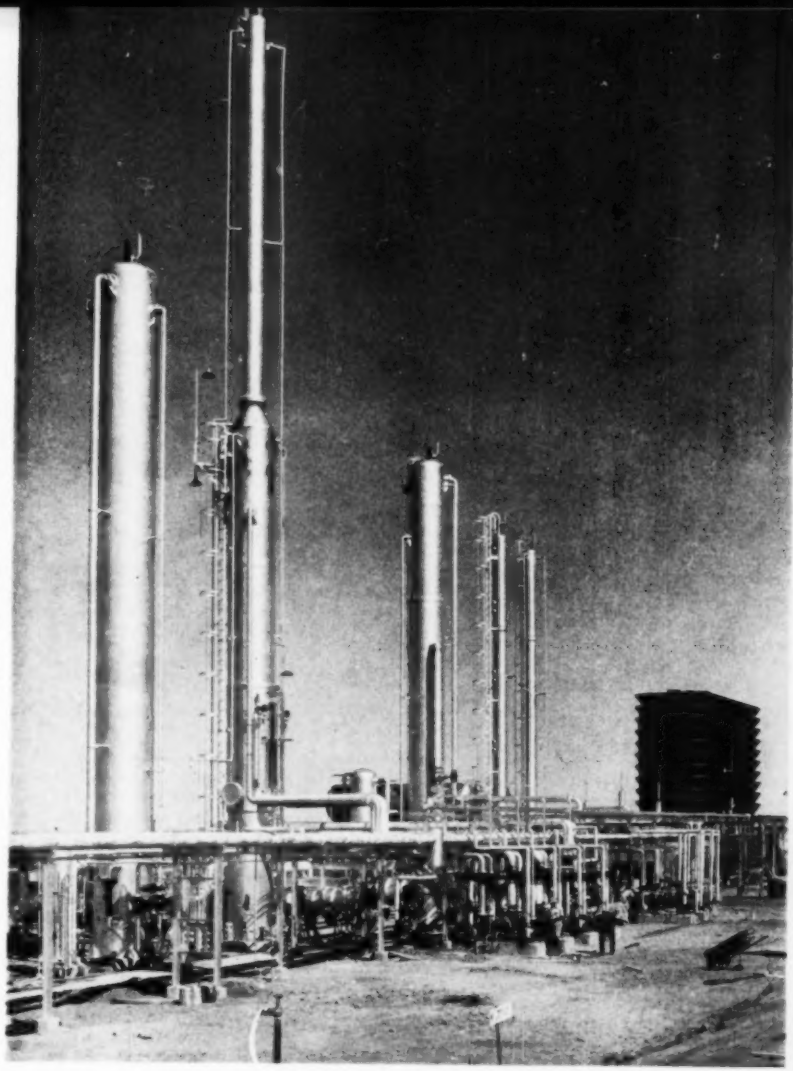
In the plant with rich oil stabilization, the methane and ethane are removed immediately after the initial absorption and are not further processed. Therefore, the entire flashing, recycling, reabsorption, and deethanizing systems are eliminated and an appreciable portion of the balance of the plant equipment is reduced in size.

There are many possible variations in the design of plants not using rich oil stabilization which may incorporate recompressors, double still systems, flash tanks, and reabsorption in various combinations. In a recent comparison, the estimated cost of a plant using the third method of rich oil stabilization was $180,000 or 15 percent less than the most economical design that could be arrived at without use of rich oil stabilization. Further, the utility requirements were appreciably less, which results in lower operating costs and quicker investment payout.

A description of the flow and equipment arrangement in the preheater-reboiler stabilizer shown in Figure 4 follows. An understanding of this system and reference to Figures 2 and 3 will explain the fundamental differences and manner of operation of the three systems.

The bubble trays in the absorption section above the feed tray function like a conventional absorber. Lean oil is admitted on the top tray and rich oil leaves from the bottom tray.

Below the feed point are bubble trays on which vapors from the stripping section contact the rich oil from the feed and absorption section, preventing stripping heat from passing into the absorption section. Actual plant operations have shown that heat exchange on these trays is complete, and that the



This picture taken at a New Mexico plant shows the primary absorber on the left then the rich oil stabilizer, lean oil stripping still and finally the two fractionating towers, the depropanizer and debutanizer.

operation of the absorption section is independent of the heat input and operating temperatures in the stripping section.

The partially preheated rich oil leaving this heat exchange section flows to a draw-off pan from which it is pumped through a preheating exchanger back to the tower above the top stripping tray. The vapors generated in the preheater are released in the tower and the finally preheated liquid flows down over the stripping trays countercurrent to the stripping vapors generated in the reboiler.

Heat to the reboiler and preheater is supplied in most cases by hot lean oil from the bottom of the still. It may, however, be supplied by steam, a direct fired heater, or a combination of these three means, depending upon the heat balance in the plant and the temperature level in the rich oil stabilizer.

Comparison of the three systems, Figures 2, 3 and 4, reveals certain important differences. Figure 4 shows actual operating temperatures while the temperatures shown on Figure 2 have been calculated using the same wet gas analysis and recoveries that correspond to the data of Figure 4. A study of these temperatures will show two very important advantages of the preheater-reboiler over the single-reboiler system.

First, the lean oil to the cooler is at 158° F. in the one system as opposed to a temperature of 210° F. in the other. The reason for this difference is the fact that the rich oil in the first case entered the preheater at 128°, and in the second case entered the reboiler at 180° F. In a plant circulating 360 gpm. of lean oil, this temperature difference of 52° F. represents an increase in duty on the cooling system of 4.1 million Btu. per hour. Additional equipment would not only be necessary to remove this extra amount of heat, but would also have to be added, together with the necessary utilities, to the heating system of the single-reboiler unit to supply the 4.1 million Btu. per hour.

Second, in the case of the preheater-reboiler arrangement, the average stripping temperature is 220° F., with a maximum temperature of 243° F. The corresponding average temperature in the single-reboiler arrangement is 133° F. with a maximum of 180° F. Because of the higher mean temperature in the first case, stripping is more complete and can be accomplished with fewer trays and less reboiler vapor.

These two differences, the lower lean oil temperature to the cooler, and the higher mean temperature of stripping, give the preheater-reboiler system a definite economic and operating advantage over the single-reboiler arrangement.

The system shown in Figure 3, which incorporates only preheating has definite limitations as compared with the other two stabilizing systems. First, the degree of deethanization is entirely dependent upon the vapor used for stripping. If complete deethanization is required, it is necessary to recycle a stripping vapor essentially free of ethane. The vapor in this event would generally be propane from the top of the depropanizer column, which would considerably increase the lean oil necessary in the top absorption section to maintain the over-all propane re-

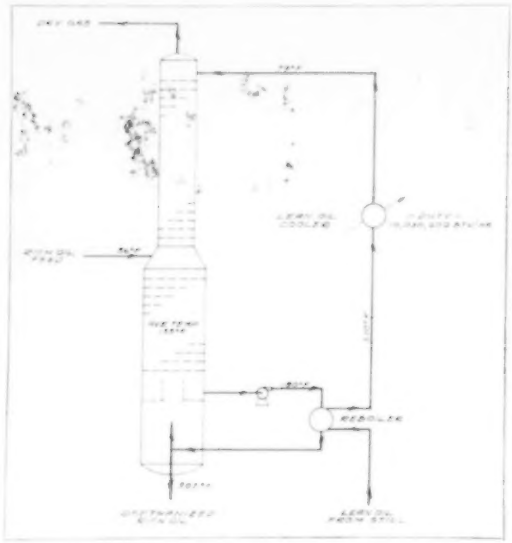


Figure 2. Rich Oil Stabilizer Single Reboiler System.

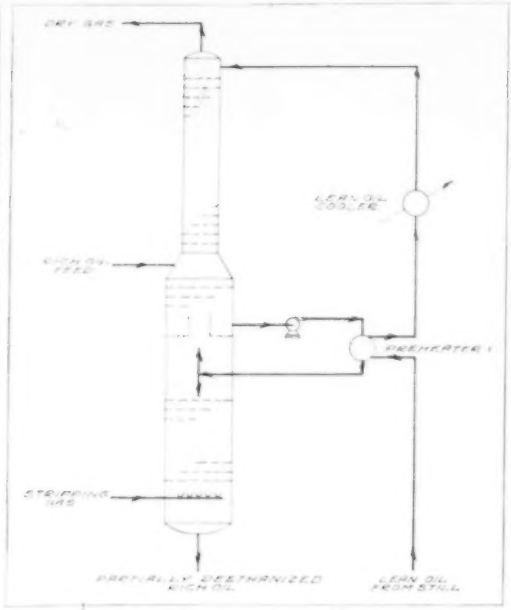


Figure 3. Rich Oil Stabilizer Single Preheater System.

covery. Second, if complete heat exchange between the rich oil and the hot lean oil is taken in the preheater, the amount of vapors generated is so great that a large heat exchanger section is required to prevent warming up of the bottom of the absorber section.

An application in which the single-preheat system may be used advantageously is where only partial demethanization and deethanization are required. Such an application is sometimes found when high pressure absorbers are located on gas transmission lines. In these cases, it is important that all of the gas except that used for fuel be returned to the transmission line at full pressure. Here a preheat of the rich oil leaving the absorber section of approximately 100° F., with the injection of wet gas at the bottom of the stripping section, will result in the elimination at full absorber pressure of about 30 percent of the methane and ethane from the rich oil.

Single-stage reboiling has not been considered practicable for processing lean gases or for high propane recoveries.[1] On the other hand, the preheater-reboiler system has been found economical to install and operate over a wide range of feed gas compositions and propane recoveries. Our experience shows that it is not possible to set an upper economic limit on the propane recovery of preheater-reboiler stabilizers, nor when a wet gas would be considered too lean for this method of deethanization, as there are too many variables affecting each design.

Table 1 gives the feed gas analysis, over-all propane recovery, and compositions of the wet gas and propane product, of two plants now in operation using preheater-reboiler rich oil stabilizers.

Although the propane purity given in Table 1 shows ethane contents between 1 and 1.5 percent, contents as low as 0.08 percent have been obtained while maintaining the same propane recovery.

The design of preheater-reboiler rich oil stabilizers is involved and to some extent empirical.

Figure 5 shows the essential stream compositions and quantities around an operating preheater-reboiler rich oil

TABLE 1

Wet Gas Composition, Vol., %	Plant A	Plant B
Methane	84.08	93.69
Ethane	7.28	3.63
Propane	5.40	1.54
i-Butane	0.62	0.27
n-Butane	1.57	0.42
i-Pentane plus	1.05	0.45
Total	100.00	100.00
Liquid Content, i-Butane plus, G.M.	1.114	0.406
Over-all Propane Recovery, Percent	90.7	80.2
Propane Recovery in Rich Oil Stab., Percent	87.5	92.0
Propane Purity, Volume Percent		
Ethane	1.50	1.13
Propane	97.08	97.83
i-Butane	1.11	0.85
n-Butane	0.33	0.19
Total	100.00	100.00

stabilizer. The first step in the design is to set the propane recovery and extent of ethane removal. An assumption of the lean oil quantity to the top of the absorption section makes it possible to complete a material balance around the tower, since all of the methane and none of the butanes will appear in the dry gas leaving overhead.

When the design operating experience is available, the assumption of lean oil quantity can be made quickly and accurately. A suggested method for computing the lean oil quantity[3] assumes equality of the ratios of the two key components in the feed and in the vapor to the absorption section. Our design and operating experience does not bear out either the assumption of the equality of the key component ratios or the suggested method of computing the lean oil.

With the material balance completed, the bottoms composition is known and an initial boiling point calculation will determine the bottoms temperature, once the tower pressure is set. At this point it is essential that the temperature level of the reboiling medium be considered and that the bottoms temperature and pressure be far enough removed from the critical conditions of the deethanized material so that the required separation is possible.

The bottoms temperature calculation is a function of the characteristics of the lean oil. Depending on the particular set of "K" values chosen, dif-

ferences of as much as 100° in the calculated and observed values were found. An empirical correction for the lean oil "K" values may be developed from operating data that is a function of the characteristics of the lean oil and the degree of stripping in the still.

The total heat input to the reboiler and preheater can be determined by an over-all heat balance around the tower. It is impossible to generalize on the distribution of the heat between the preheater and the reboiler as each design must be studied from the standpoints of feed composition, propane recovery, temperature, and pressure. A recent article[2] states that it is usually not economical to put more than 30 percent of the heat into the preheater. We have not found any justification for such a statement. One plant now in operation takes approximately 60 percent of the heat in the preheater and the remaining 40 percent gives sufficient reboiler vapor to completely deethanize the rich oil. A fairly good approximation is, the richer the feed and the higher the recovery, the more heat will be required at the reboiler.

With the amount of heat to the reboiler fixed, the bottom tray temperature is assumed. A heat balance around the bottom of the tower sets the amount of vapors to the bottom tray, which when added to the bottoms liquid gives the tray liquid composition. An initial boiling point calculation is made to check the bottom tray temperature assumption.

The top stripping tray liquid can be determined by tray to tray calculations over the stripping section. The point of methane injection into the tray calculations was originally approximated. When operating data became available, a method was devised to determine the amount and point of injection.

To determine the vapors rising to the absorption section, heat balances and flash calculations are made around the heat exchanger section. Knowing the dry gas composition and quantity from the over-all material balance, and the assumed lean oil, this vapor can be checked with an absorption calculation.

If this check is reasonably close, the assumptions made in the course of the calculations were correct. If the composition does not check, new assumptions as to lean oil quantity, heat distribution between the preheater and reboiler and number of trays, must be made and the calculations repeated.

Although this discussion has been limited to rich oil stabilization in gasoline plants, the process is, of course, equally applicable to refinery and cracking plant fat oils.

A plant nearing completion at Big Lake, Texas, will use a preheater-reboiler type of stabilizer into which the wet gas will be fed directly without an initial absorber. Wherever absorption pressure will permit such a design, it will further reduce initial plant investment.

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Figure 4. Rich Oil Stabilizer Preheater and Reboiler System.

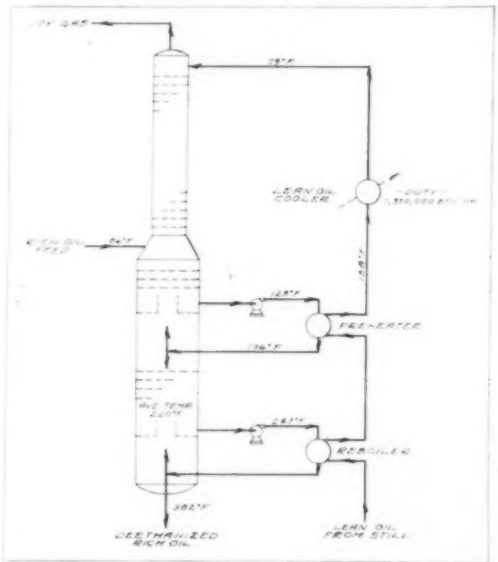
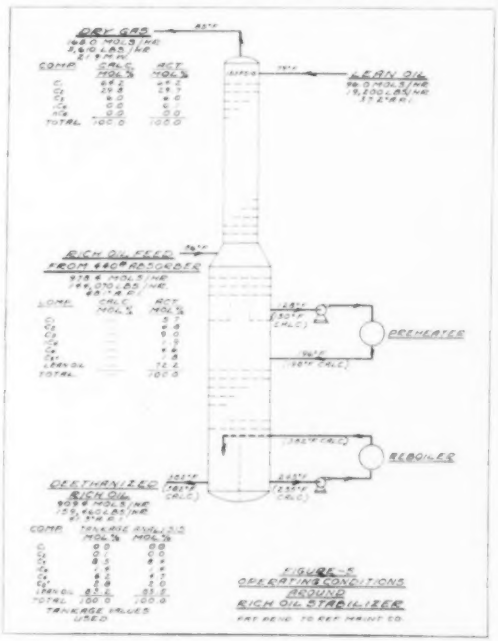


Figure 5. Operating Conditions Around Rich Oil Stabilizer.



Shell courses and regenerator head for the 150-foot cat cracker being assembled from rolled sections were shipped to Big Spring, Texas, from Los Angeles. Notice the temporary internal bracing in shell course on right.

Unique Method Sets Fast Record For Cat Cracker Erection

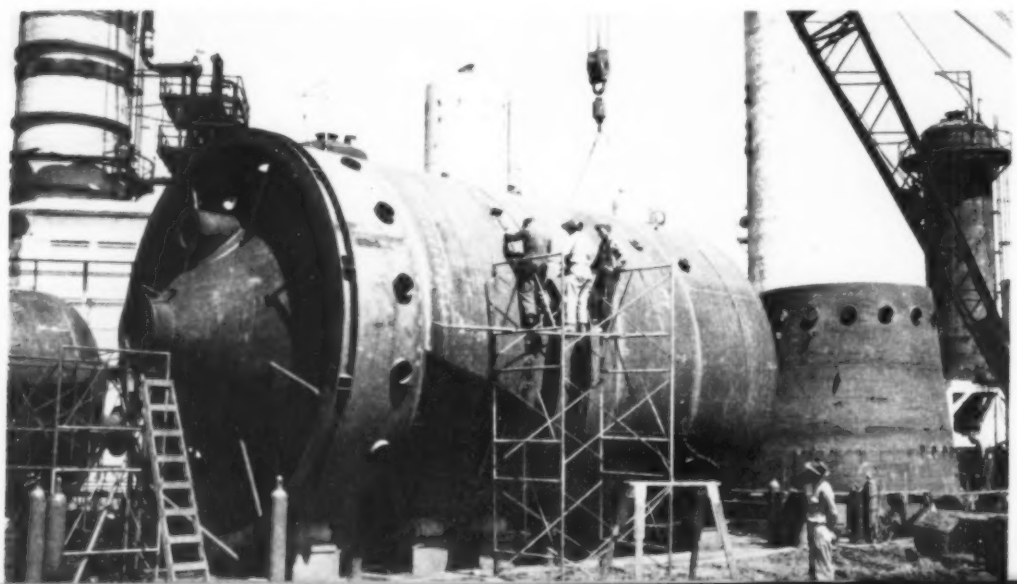
THE 150-foot catalytic cracking tower at Cosden Petroleum Corporation's refinery at Big Spring, Texas will be on stream well ahead of schedule, due to the unique methods employed in its construction.

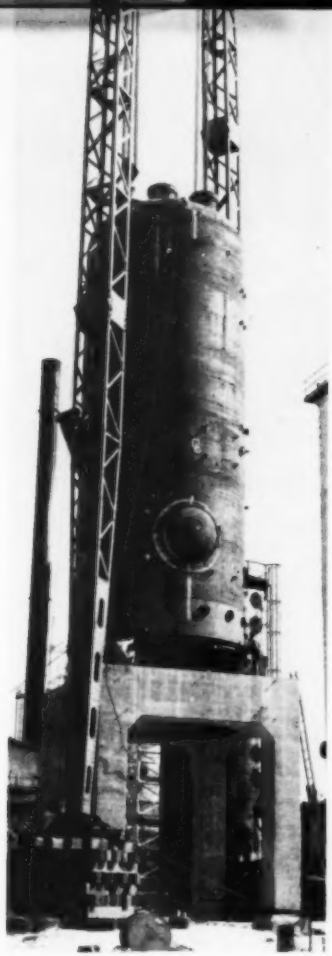
Usually, towers of this size have been constructed vertically. Piece by piece, shell sections, heads, internals, etc., had to be raised and welded in position, which made this method of construction slow and sometimes inaccurate.

This recently completed tower, measuring approximately 20 feet in diameter by 150 feet in height, including the concrete foundation, is constructed to API-ASME code. It consists of a regenerator and a reactor connected by an intermediate skirt, with a stripper, direct fired air heater, flue gas steam disengaging drum and other auxiliaries attached. The gross weight of the assembly is in excess of 250 tons.

In fabricating and erecting this tower, Southwestern Engineering Company

Below—Shell courses of regenerator being welded together. Heavy trunnions allow rotation of the unit so that welding could be done rapidly and with great accuracy. The intermediate skirt in the right background was assembled vertically.





The 110-ton regenerator is placed in position on the 26-foot reinforced concrete foundation with the aid of two large gin poles.

Reactor, intermediate skirt, and stripper assembly, weighing 85 tons, is lifted into position on top of the regenerator.

decided that if the 110-ton regenerator and the 85-ton reactor and skirt assembly could be lifted into position by crane and gin pole, the fabrication of these units could be done more accurately and in less time at ground level on a horizontal slab of concrete.

Working with Pacific Crane and Rigging, Inc., of Los Angeles, the contractors devised special hoisting equipment including two 150-foot gin poles with connecting bridge capable of handling up to 600 tons. This equipment made it possible to elevate various assemblies into position.

Tower Shipped in Sections

The engineering company then proceeded with the forming and rolling of shell courses and other parts, and the completion of sub-assemblies in its Los Angeles plant. The tower was shipped to the job site in prefabricated sections as large as possible within rail limitations. The regenerator, measuring 19 feet, 8 inches by 50 feet, the reactor (13½ feet by 40 feet) and the intermediate skirt (26 feet long) were shipped in a number of separate shell courses, each in half cylinders. Heads for these vessels were shipped complete or in sections, depending on their diameters. Because of the relatively smaller size, the stripper, direct fired air heater and flue gas steam disengaging drum were each shipped completely assembled.

At the job site, shell courses, head sections, etc., of the regenerator and reactor were each assembled on a horizontal axis, while the intermediate skirt, a truncated right circular cone, was assembled vertically. During assembly, temporary internal bracing maintained the proper shape of the large-diameter shell courses. The reactor and regenerator rested on heavy-duty trunnion rollers especially constructed to support the great weight and permit rotating of the vessels for efficient, accurate, ground-level welding.

Foundation Erected

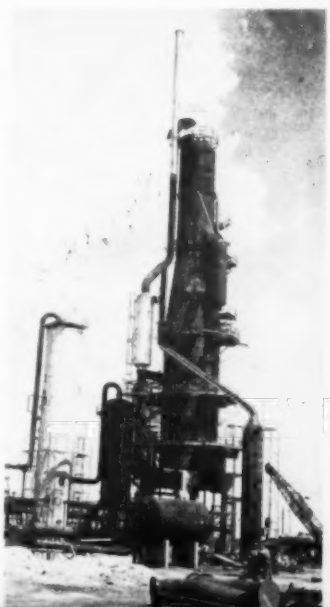
While welding proceeded, a 26-foot high steel reinforced concrete foundation was erected. When the 110-ton regenerator assembly was completed, it was lifted upright and elevated onto the foundation. Removable lifting lugs were provided on the assembly so hoisting lines could be attached.

The stripper, 5½ feet in diameter by 28 feet in length, was attached to the reactor while the latter was still in a horizontal position. The reactor and stripper assembly was then lifted to a vertical position and placed on top of the intermediate skirt which was fabricated in a vertical position. These two subassemblies were welded together and this 85-ton mass was elevated (using the double gin pole arrangement) more than 75 feet and welded in place on the regenerator.

This method of shop fabrication, knocked-down shipment, horizontal ground assembly and erection of complete units proved highly successful. Field work consumed only 117 days and the finished tower was within ½ inch of the specified height and less than 3/16-inch out of plumb. These differences officials considered negligible in view of thermal expansions and wind loading.

Reactor is raised and placed on the top of the intermediate skirt, where it is welded in position.

Photo below—Putting the finishing touches on the large tower by connecting auxiliary equipment.



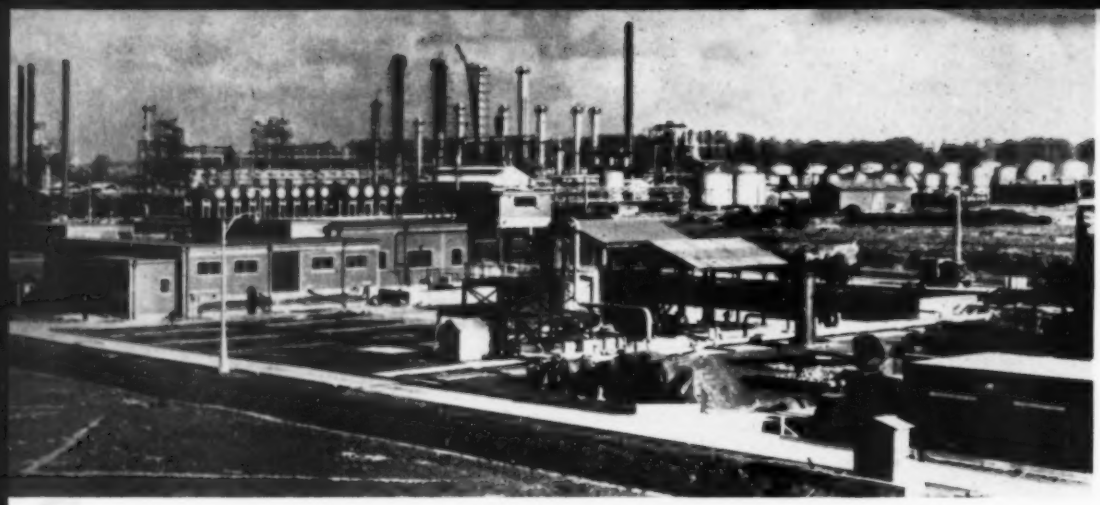


Figure 1. New Shell Chemical Plant, Stanlow, near Ellesmore Port, Manchester (England) Ship Canal.

Variety of Special Pumps In English Chemical Plant

A discussion, prepared jointly by technical staff members of Shell Chemical Manufacturing Company and Sigmund Pumps, Ltd., describes pumping problems in Shell Chemical's new plant at Stanlow

THE new Stanlow plant of Shell Chemical Manufacturing Company, Ltd., has been designed for a maximum of automatic control and thus, while it will make a relatively small demand on the country's labor force, it has necessitated a high capital expenditure for specialized instruments and equipment embodying the latest advances in petrochemical technology.

The chemicals produced, apart from their solvent use, have a wide application in synthesis in industry and are processed from petroleum gases which not many years ago were useless refinery by-products. These gases result from "cracking" oil at high temperature and low pressure and the aim is to produce fractions containing three or four carbon atoms. Propylene is the three-carbon compound in the lighter fractions and it is reacted with sulphuric acid; the resulting alkyl esters are converted to isopropyl alcohol which, in turn, becomes the basis for many other chemicals. The C_4 fraction, after treatment to remove unwanted constituents, gives butylene and butane, the former, in turn, yielding secondary butyl alcohol and methyl ethyl ketone. The initial range of solvents from the Stanlow plant will be: isopropyl alcohol, isopropyl ether, acetone, diacetone, methyl isobutyl ketone, mesityl oxide, secondary butyl alcohol and methyl ethyl ketone.

The propelling and circulating of these liquids from one place and sec-

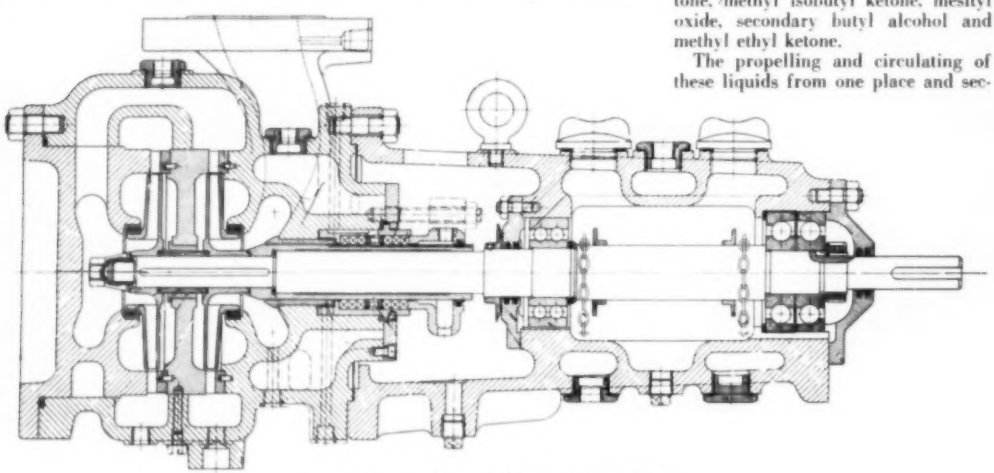
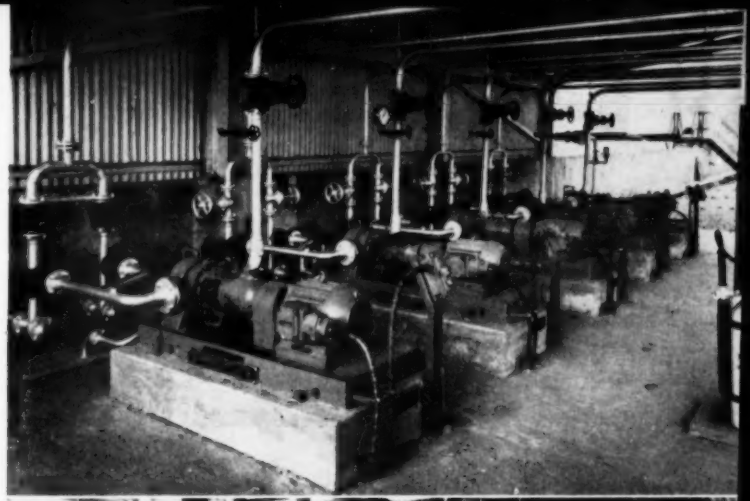


Figure 2. Sectional View of a Typical Two-Stage Unit.

***PUMPING** extremely volatile, toxic and/or expensive liquids at high temperatures constituted a major problem when Shell Chemical Manufacturing Company, Ltd., went about building its new plant near Ellesmere Port on the Manchester ship canal. This plant, adjacent to the existing Stanlow refinery and the new Shell refinery, now under construction, was originally designed as an independent unit to produce 24,000 tons of solvents annually by the pyrolysis of gasoil. However, once the new refinery is completed, the solvents will be manufactured from gas produced during normal refinery operations, thus making the whole an integrated process, starting from crude oil and ending with petroleum chemicals. How the pumping problem was met is described in the accompanying article.*



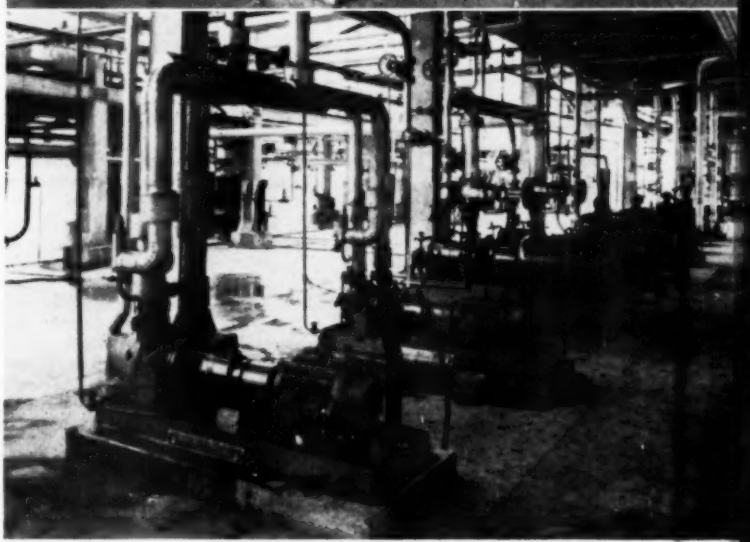


Figure 3. Photo at top: Pumping Station showing Units with Horizontal Branches with Inlet and Outlet Opposite.

Figure 4. Photo at bottom: A Batch of High-Temperature Process Type Pumps, Including Multistage Barrel Types and Single-Stage Units with Vertical Top-Top Branches.

tion to another and through stills, tanks, columns and heat exchangers is done by a variety of special pumps. See Figure 2. After prolonged discussions about design, features and materials, an order was placed for well over 250 centrifugal pumps, covering the majority of all pumping conditions in the new plant. (Figure 3.)

Some of the liquids are extremely volatile, others toxic; many are pumped at high temperatures (some above 600° F.); and again some are very expensive, costing in some cases over ten shillings per gallon. All kinds of liquids, from propanes and butanes to viscous fuels have to be dealt with. These conditions demand extreme reliability of the pumps throughout, but especially of the shaft sealing member, in order to reduce leakage to an absolute minimum.

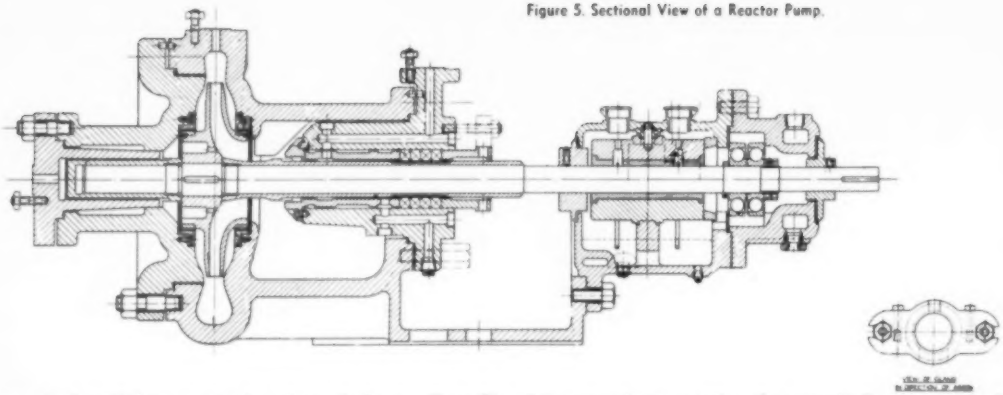
The large number of pumps involved created a considerable maintenance problem, as it seemed quite out of proportion to have a spare pump available for each duty, as is often done in refineries. To deal with all these aspects, all the duties to be performed were tabulated and then grouped. Thus, three basic pump designs were selected; a single-stage pump, a two-stage pump and a multi-stage barrel pump. Within these groups steps were taken to keep variations of parts to a minimum by employing the same internal parts in all three groups. There are single-stage, two-stage and multi-stage barrel pumps all employing the same impellers and wear rings, and between single and two-stage pumps only one bearing assembly is used.

Thus, about half of the total number of pumps supplied use the same wear rings, shaft sleeves and other wearing parts in single, two-stage and multi-stage units, and even in some vertical sump pumps. There are only two sizes of impellers used in these pumps, differing only in width, thus leaving all other components similar. A second batch of about 80 pumps again uses another size of impeller and relevant components, one bearing assembly only being used for this group.

More than three-fourths of all the pumps have only two sizes of bearing assemblies in single and two-stage pumps. Inevitable problems of maintenance during operation are much facilitated by this method and the work of storekeeping reduced to a few items only, which not only simplifies maintenance but also reduces the outlay for spare parts.

As for the basic design, most of the pumps employ diffusers in either a ring casing or a volute casing. This has, in the case of ring casings, simplified the positioning of pump branches, the intakes being either horizontal, left or right, with outlets opposite, or top-top in an otherwise similar casing and similar direction of rotation. Apart from this consideration, however, diffusers were chosen for another important rea-

Figure 5. Sectional View of a Reactor Pump.



son. As is well known, simple volute type pumps have a heavy radial thrust, set up by pressure conditions in the volute against the shaft. This tends not only to deflect the shaft in one direction, but also to create various states of deflection and vibration when controlling pump outputs during operation, which is done automatically by appropriate instrumentation.

The result of this unsteadiness of the shafts is quick wear of packings and shaft sleeves and difficulty in controlling leakage. Diffusers eliminate largely any radial thrust against the shaft and thus tend to reduce leakage to an unavoidable minimum. A leakage of one gallon per hour, when the price of the liquid is ten shillings per gallon, would constitute a loss of £12 per day, a loss which is in almost all cases total, because most of the liquids evaporate on getting into the atmosphere. Provision is made for inserting Sigmund mechanical seals without any further modification, and after first using soft packing with appropriate and, in some cases, rather elaborate sealing systems, mechanical seals are now being installed for the more onerous duties.

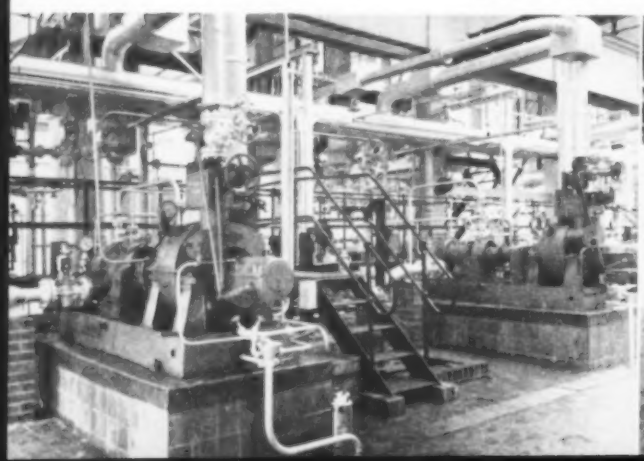
As a further means of reducing gland leakage, all stuffing boxes are kept under suction pressure only, this being accomplished by having the pump intake at the stuffing box end. This design feature has the further advantage of washing solids, such as crystals or grit, away from the stuffing box, instead of against it, as is the case with the more orthodox pump design. A cooling chamber surrounding the suction improves suction flow conditions on volatile and/or hot liquids. The general type of pump supplied is shown in Figure 4.

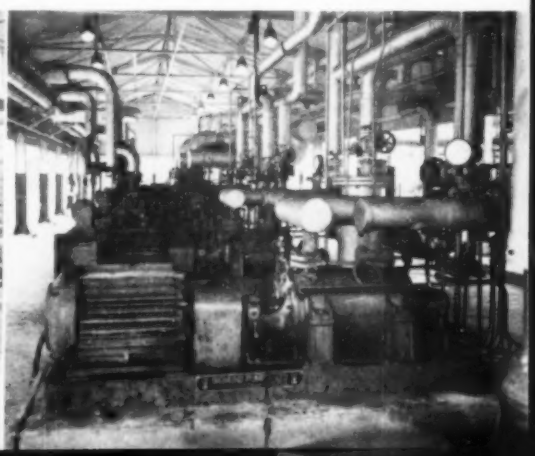
Finally, it may be of interest to give details of a reactor pump dealing with an onerous sludge consisting of light hydrocarbon and acid. This pump is shown in section in Figure 5 and Figure 6 shows reactor pumps handling a mixture of hydrocarbon and acid. Again, the suction inlet at the stuffing box end is a typical feature. In this case, a special sealing system was thought necessary, with injection and throttle clearances, to keep the amount of sealing liquid used to a minimum. The liquid used for sealing is concentrated sulphuric acid, and stuffing box parts, as well as bedplates, are lead lined. Due to the length of the overhung shaft portion thus required, it was found necessary to incorporate an internal bearing. This could be done in this instance because the acid pumped, though extremely corrosive, is a good lubricant. Special materials are used throughout for this pump and the shaft protecting sleeves and bearing bushes are faced with Colmonoy No. 6, an extremely hard and corrosion-resisting material.

For a considerable number of duties, where light hydrocarbons are pumped at high temperatures and pressures, barrel pumps were supplied with from 3 to 8 stages. In these, only 2 joints are used, one of which is under high pressure, so that the danger of leakages from a multitude of vertical casing joints is reduced to a minimum. Figure 7 shows a group of Sigmund high pressure barrel pumps.

The supply of pumps for the above plant involved the solution of an array of problems, which could only be done through the closest co-operation between the plant staff, as future operators of the equipment, and the pump manufacturer.

Figure 6. Photo on left, below: Reactor Pumps handling a mixture of hydrocarbon and acid.
Figure 7. Photo on right, below: Group of High-Pressure Barrel Pumps.





Drainage Time for Bubble Cap Columns

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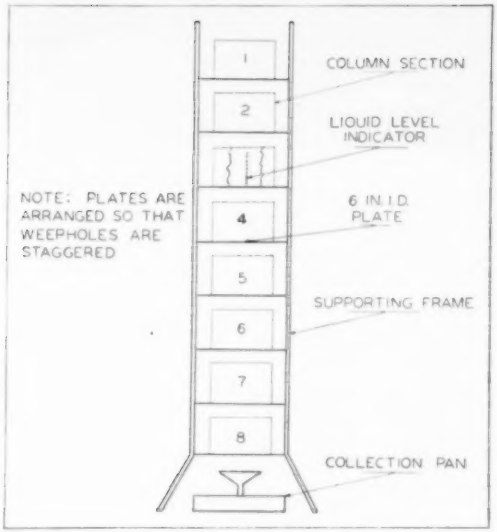


A COLUMN employing bubble caps usually has an overflow dam which insures a minimum height of liquid on the plate during operation. As the column is taken "off-stream," this overflow dam would retain that minimum height of liquid if no means were available to remove the liquid. If the height of the vapor risers is below the height of the overflow dam, the liquid will drain from the plate down through vapor risers, assuming the velocity of the vapor has fallen sufficiently enough to permit the liquid to do so. After the lower height of the two (vapor risers and overflow dam) is reached, the remaining liquid has to be drained by one or more small holes placed in the plate for this purpose. This small hole is referred to as a weephole. Since the vapor risers and downcomer areas usually are approximately 15-30 percent of the total plate area, the time, which is consumed in draining the column down to the top of the chimneys, is negligible as compared to the time consumed for the remaining drainage by the weephole which is usually about ¼-inch-⅜-inch in diameter.

The drainage by the weephole can be compared to a flow through an orifice with the pressure drop across the orifice being the liquid height on the plate. If this assumption is true, the drainage rate could be calculated directly from the orifice equation provided the discharge coefficient were known. The discharge coefficient is dependent upon the Reynolds number and, as will be brought out later, the Reynolds number changes sufficiently during the drainage to cause a change in the discharge coefficient.

To arrive at the time required for this drainage, a "column" of eight plates with an inside diameter of six inches was set up as shown in Figure 1. All plates were open to the atmosphere to give the same pressure above and below the plate. This assembly simulated an actual column since the pressure in a column would become the same throughout once the downcomers or vapor risers are free of liquid. Several sizes of weepholes were studied and it was found that, if the weephole was less than ¼-inch in diameter, liquid remained on the plate after drainage had stopped due to the surface tension. The height of liquid remaining varied with the liquid and the size of the weephole. Approximately 3/16-inch of water remained over a 1/16-inch diameter weephole in a plate of 1/16-inch thickness at 65° F. No study was made as to the height of liquid which would remain under varying conditions. The observed conditions only served to show the necessity of a larger weephole to accommodate effectively the drainage of a variety of liquids. Most of the data were obtained on ¼-inch and ⅜-inch weepholes which are thought to be the sizes usually used in the petroleum industry. The holes were drilled in the plate, which was about 1/32-inch thick, and the bottom of the plate was then sanded until the plate thickness at the weephole was about 1/64-inch. The weepholes were then checked for correct diameter by calipers and also by drainage time. Each column section was filled to the 6-inch mark and allowed to drain separately. When each section drained in an elapsed time not varying more than five seconds, the weepholes in the plates were considered to have the same diameter.

THE TIME required for a fractionating column to drain, after it has been taken off-stream, is a factor which enters into the routine operation of many plants employing distillation. The literature reports little, if any, experimental data on this operation and, to the authors' knowledge, no method of calculating this drainage time has been presented.

TABLE 1

FLUID	Temp. °F.	Viscosity (Centipoises)	Density gr. per cc.
Water	78	0.91	1.0
Water	60	1.14	1.0
Carbon Tetrachloride	65	1.03	1.5
Carbon Tetrachloride	78	0.90	1.5
Gasoline	78	0.45	0.73
Light Lube Oil	78	0.61	0.84
Light Lube Oil	67	0.75	0.84

The liquids, upon which experimental data were obtained, were water, carbon tetrachloride, gasoline and light lube oil. The physical properties of these liquids are given in Table 1.

The experimental technique used in obtaining the experimental data was as follows:

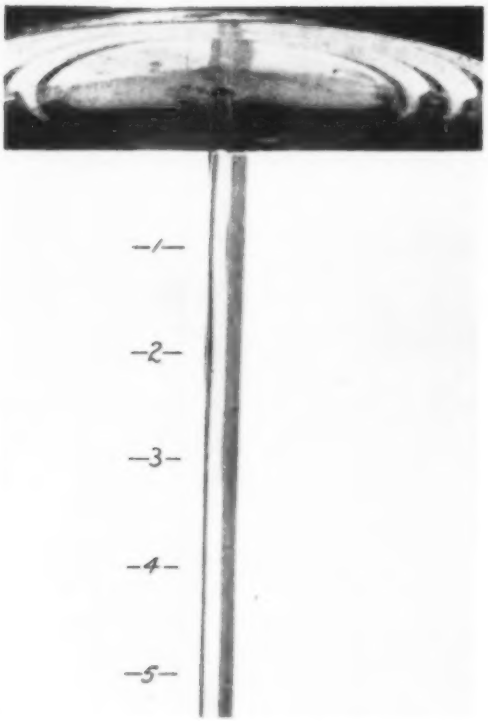


Figure 2. Weephole Draining a Light Lube Oil, Reynolds number 8000, Liquid Height of 5½ Inches on Tray.

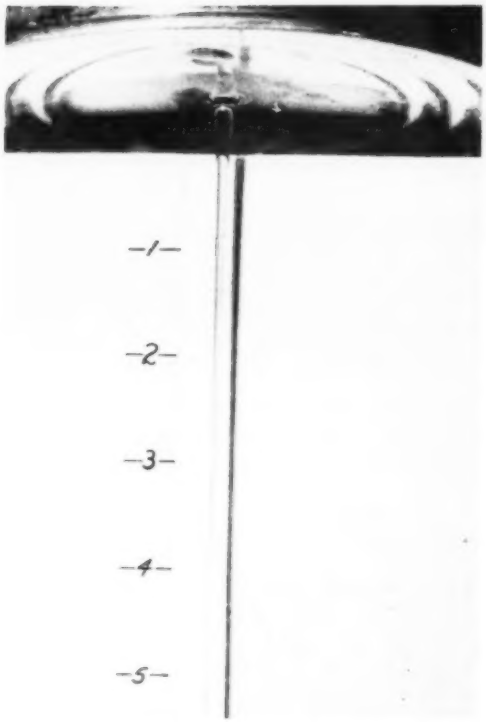


Figure 3. Weephole Draining a Light Lube Oil, Reynolds Number 1800, Liquid Height of ½ Inch on Tray.

Each column section was filled with the liquid and allowed to drain so as to "wet" the plate and weephole. Then the column sections were filled to the desired level and the liquid was held on the plate by means of tape over the weephole from the bottom side. After all plates were checked to insure they were level, the tape was removed from all the weepholes simultaneously by several operators working in coordination. A stop watch was started as the liquid began to flow.

As the liquid height on each plate decreased, the time was recorded at 1-inch intervals for each plate. A plate was considered to be drained when the liquid stopped flowing as a stream and began to come out in the form of drops. The level of the liquid on the plate at the time the flowing stopped was estimated to be less than 1/32-inch for both sizes of weepholes.

The above technique was carried out for liquid heights starting at 3, 4, 5, and 6 inches on the four liquids. When the liquid was changed, the column sections were washed with carbon tetrachloride and allowed to dry. Then they were washed with the liquid to be used before another run was made.

Various attacks were used in an attempt to analyze the experimental data and to correlate the results. It was noticed that the time interval between the emptying of two successive plates was constant for any given liquid if the height at the beginning of the drainage was the same on each of the plates. This relationship was found to be true by plotting the drainage time versus the plate number, which resulted in a straight line. However, any one line was only good for the one liquid at the conditions under which the experimental data were obtained.

Numerous attempts were made to arrive at a correlation to determine the drainage time as some function of the variables causing the different drainage periods. Complications developed in this analysis since, during the period of drainage, the flow through the weephole changed from turbulent to streamline flow. This change was visible, as can be seen in Figures 2 and 3. Figure 2 shows an oil with a liquid height of 5½ inches which has a Reynolds number of 8000. Figure 3 shows the same oil at a liquid height of ½-inch with a Reynolds number of 1800.

Extrapolated values from Tuve and Sprenkle[1] were used as the discharge coefficient in order to check experimental data in the equation

$$q = CA_o \sqrt{2g\Delta h} \qquad (1)$$

where q = cu. ft. per sec.
C = discharge coefficient.
A_o = area of weephole in sq. ft.
g = 32.2.
Δh = differential pressure drop across weephole in feet of fluid

In the turbulent region the results checked within 10 percent but, at Reynolds numbers less than 5000, the results disagree. This disagreement indicated that the discharge coefficients were changing more than was expected in the lower Reynolds numbers. Some method was needed to determine the extent to which the discharge coefficient changed during the drainage.

Assuming that equation (1) holds true if small increments of Δh are taken, and the correct C for that particular Δh is used, the following equation was developed to determine the discharge coefficient at different liquid heights.

Multiplying equation (1) by $d\theta$ gives

$$q d\theta = A_o C \sqrt{2g\Delta h}\, d\theta \qquad (2)$$

also

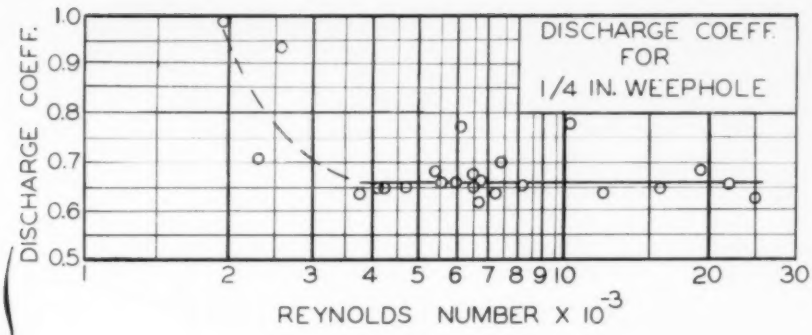
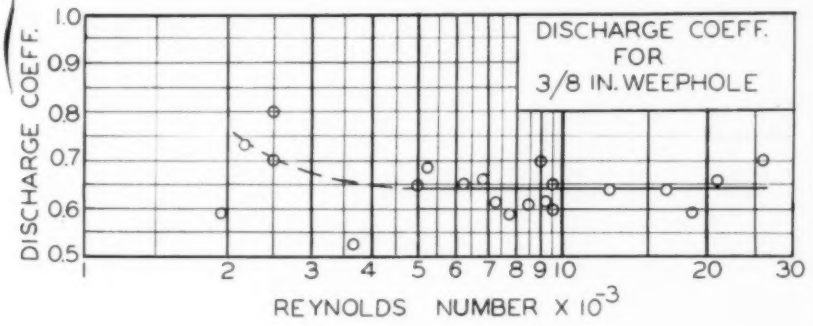


Figure 4



$$qd\theta = -dV \quad (3)$$

where θ = time in seconds
V = volume in cu. ft. remaining at time θ

also

$$dV = Ad(\Delta h) \quad (4)$$

where A = area of plate in sq. ft.
Δh = height of liquid on plate in ft. (equivalent to the differential pressure drop across the weephole).

Substituting $-Ad(\Delta h)$ for $qd\theta$ in equation (2)

$$-Ad(\Delta h) = A_o C \sqrt{2g\Delta h}\, d\theta \quad (5)$$

Integrating between limits and solving for C gives

$$C = \frac{2A\left(\sqrt{\Delta h_1} - \sqrt{\Delta h_2}\right)}{A_o \sqrt{2g}\,(\theta_2 - \theta_1)}, \quad (6)$$

Equation (6) was used to determine C at various liquid heights taking the increments of Δh not more than one inch. The results of determining the discharge coefficient are presented in Figure 4. The Reynolds numbers were calculated in the usual manner.

Upon studying the data along with Figure 4, it was seen that most of the time of the drainage was consumed in the lower values of Reynolds numbers which would mean the flow rate would vary inversely with the Reynolds number. From this conclusion, the time for drainage would vary with some function of the Reynolds number. The diameter of the weephole would not change and the velocity was dependent upon the height of liquid, viscosity and density. The heights of the liquids were the same; therefore, the time was dependent upon some function of the viscosity and density.

Various relations were tried to bring the drainage time for different liquids together as a function of time, viscosity and density. The empirical relation, which gives the best over-all results, was found to be

$$\frac{\theta\,\mu^{1/2}}{\rho^{1/3}}$$

where θ = time in min. per sq. ft. of plate area.
μ = viscosity in centipoises.
ρ = density in grams per cc.

Their values are plotted in Figures 5 and 6 for $\frac{1}{4}$-inch and $\frac{3}{8}$-inch weepholes. The liquid level refers to the height of liquid at the time the drainage starts. The relationship was worked out on the 6-inch i.d. column and the drainage times converted over to a plate of one square foot covered with liquid. This square foot of area, upon which θ is based, is taken as the total plate area minus the sum of the downcomer area and the riser or chimney area.

Experimental results on all the liquids studied check Figures 5 and 6 within 15 percent with most of the experimental results checking these figures within 10 percent. Several check runs were made at liquid temperatures varying from 32° F. to 100° F. and the results checked within 15 percent of the ones obtained using Figures 5 and 6.

Time did not permit the use of liquids covering a wide range of viscosity, but the liquids used indicate the results check for liquids having viscosities of 0.2 to 2.0 centipoises, in the temperature range of 32° F. to 100° F.

It is hoped that fractionator designers and operators will have a better idea of the factors involved in the drainage of columns as a result of this investigation.

A 2-foot i.d. column of 15 plates is used to separate a 50-50 mixture of pentane and hexane. The column is operating at atmospheric pressure, top temperature of 95° F. and bottom temperature of 155° F. The vapor risers and the downcomer are 20 percent of the plate area and have a height of three inches. There is a $\frac{1}{4}$-inch weephole in each plate for drainage.

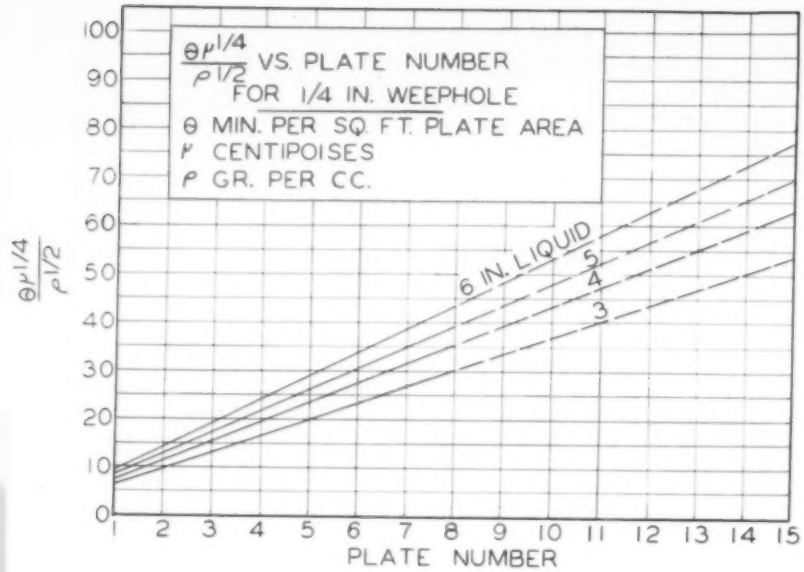


Figure 5

The drainage time is determined as follows:

Total plate area = 3.14 sq. ft.
Plate area covered by liquid = (1—.2)(3.14) = 2.51 sq. ft.
Pseudo viscosity of the 50-50 mixture at the average column temperature = 0.22 centipoise.
Pseudo density of 50-50 mixture = 0.65 grams per cc.

From Figure 5, $\frac{\theta \mu^{1/4}}{\rho^{1/2}}$ for 15 plates with 3-inch liquid has a value of 53, therefore

$$\frac{\theta\,(.22)^{1/4}}{(.65)^{1/2}} = 53$$

$$\theta_{1\ \text{sq. ft.}} = 62.5 \text{ min.}$$

$$\theta_{2.51\ \text{sq. ft.}} = \underline{\underline{157 \text{ min.}}}$$

REFERENCE

[1] Tuve, G. L., and Sprenkle, R. E., "Orifice Discharge Coefficients for Viscous Liquids," Instruments, **6**, (1933).

ACKNOWLEDGMENT

The authors wish to express their appreciation to the Magnolia Petroleum Company for the support of a fellowship under which this experimental work has been performed. This phase of fractionator design represents some of the initial studies which are being undertaken through this fellowship.

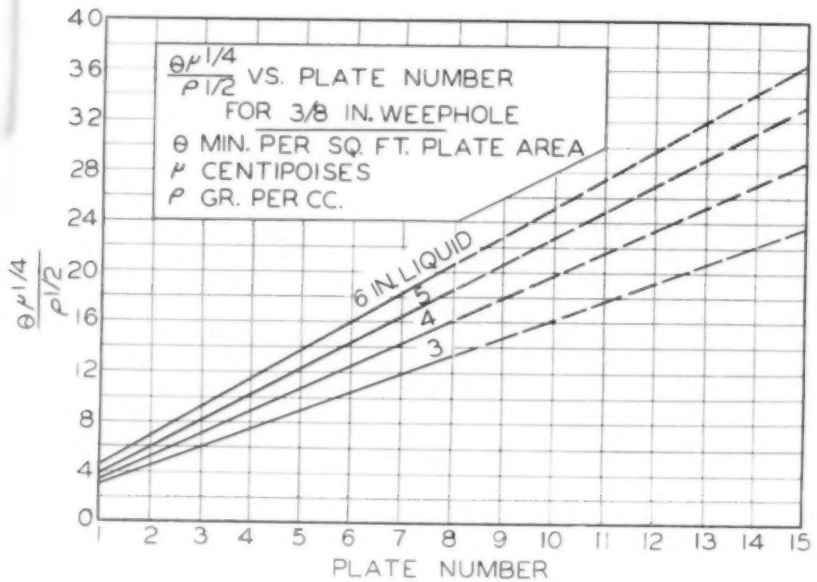


Figure 6

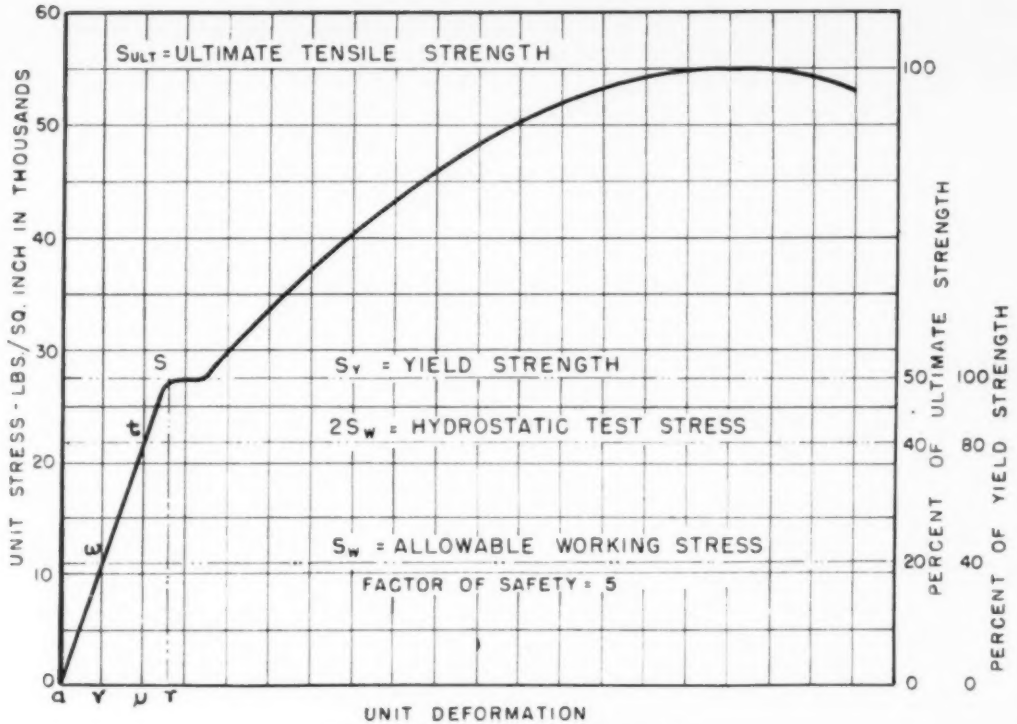


Figure 1. Schematic Stress-Strain Diagram for Mild Steel.

Factor of Safety Versus Factor of Utilization

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IN designing a vessel for a given set of conditions, the calculation of the strength of its component parts resolves itself into the determination of an allowable working stress for the material selected and the application of the appropriate formulas to obtain the thickness of the vessel wall. The solution of the problems of design generally entails an understanding of the conditions of service, a knowledge of the strength of the materials subjected to such conditions, and an evaluation of the margin required between actual service conditions and failure.

Generally, the strength of the material is defined in terms of loadings disclosed by physical tests which will produce some form of failure. It is obvious, therefore, that a stress calculation is associated with a comparison of the stresses in terms of failure. Failure of a structure should signify that condition where the material of the structure is no longer capable of sustaining the applied loading without undue deformation. This condition obtains when the actual stresses correspond to stresses approaching the ultimate strength, the yield point, the elastic limit, or to stresses considerably below any of these values, depending upon the type of material, the operating conditions, the mode of load application, and the type of stress.

For the more commonly used ductile materials in pressure vessel applications, and at temperatures between a normal ambient and 650° F., the yield point and ultimate strength provide the rational limits of failure. It is, then, necessary to apply some relation as the function of the stress at failure to obtain the working stress. The "factor of safety" is the term most commonly applied to denote the relation between these two stresses. As usually expressed, the factor of safety is the ratio of the stress which will cause failure to the design stress and is indicative of the margin of safety applied to the structure.

$n = Sf/S_s$ where n = factor of safety
S_f = stress at failure
S_s = design stress

A factor of safety, which may better be termed a "factor of utilization," is a measure of the degree of the strength of the material that may safely be utilized in a structure in consideration of the uncertainties of existing stresses or conditions. The factor of utilization is a number selected as good practice on the basis of several considerations and past experience some of which,

with reference to steel plate structures are as follows:

A) The physical characteristics of the materials of construction under operating conditions.

B) Loadings and restraints not considered in the formulas used to determine the thickness of component parts.

C) Fabrication procedures and practices that influence the strength or apparent rigidity of the structure.

D) Consideration of chemical corrosion, oxidation (rusting), abrasion, impact, vibration, repeated or variable loading, or any other action or effect tending to reduce the thickness or strength of the structure at any point and not considered in the original formulas for determining the thickness.

E) The degree of risk or economic safety or the hazard to personnel and property if a failure should occur at the location or site where the vessel will be used.

F) The estimated period of time that the vessel may be used (i.e. life of the vessel) for the operating conditions considered in the design.

Pressure vessels and steel plate structures in general are built of ductile materials. Considerations contributing to the failure of such materials should be given due value in the selection of a factor of safety.

The usual design for vessels is on the basis of steady or relatively slowly varying stresses. For this type of loading,

A) Failure may be considered when the material begins to yield. This is an easily determined value for materials usually used in plate structures. When the yield point is not well defined, the stress at which a permanent deformation is 0.2 percent may be taken as the yield point.

B) Failure may occur by rupture at stresses beyond ultimate tensile strength of the material.

C) Local concentrations generally do not contribute appreciably to failure unless the stress caused by the concentrations or combined with residual or internal stresses of the structures considerably exceed the yield point.

D) Failure may be also considered as determined by the limiting value of the imposed load instead of stress. Such cases are encountered where the magnitude of the elastic deformation is critical, or the stresses are not proportional to the external loads.

E) Failure from instability of the structure may be a controlling factor in which case the safety factor should be based on the critical stress. In such cases, the failure may occur at stresses considerably below the elastic limit of material.

Under some considerations of loading, alternating stresses are imposed on the structure. These may vary from no stress to maximum tension or compression, or from maximum tension to maximum compression and vice versa. Shock loadings may be considered in the same category. For this type of loading,

A) Failure may be predicted on consideration of the endurance limit of the material. This is an easily determined value for the usual materials of construction.

B) Failure is caused by fatigue of the metal at stress smaller than ultimate strength and the magnitude of which decreases as the number of cycles of stress increases.

C) Local concentrations contribute materially to failure.

1a. On the basis of type of failure, and mode of loading of the aforementioned conditions, a suitable factor of safety may be applied to the proper controlling factor.

In pressure vessel design, the factor of safety is usually selected and stipulated for use in various codes and specifications so that when the minimum ultimate stress of the material is divided by the factor of safety, a safe working or design stress is obtained.

This practice should not be misconstrued as necessary to base the factor of safety on the ultimate stress, since the factor may actually be considered as based on the yield point of the material which, for the majority of the steels used in pressure vessels, is about one half of the ultimate stress.

As an example, the ASME Code for Unfired Pressure Vessels recommends a factor of safety of 5 with reference to the ultimate stress; that is, for a steel having a minimum ultimate stress of 55,000 psi., the yield point is approximately 27,500 psi., while the design or working stress is 11,000 psi.

This indicates a factor of utilization of 0.4 or a design stress which is 40 percent of the failure stress, based on the yield point.

The stress at test pressure by this code for vessels built of this material is 22,000 psi., or 80 percent of the failure stress.

Figure 1 indicates the relation of the working stress with the yield point and ultimate strength of a steel with 55,000 psi. ultimate tensile strength.

It may be remarked that the area under the stress-strain curve represents the energy stored in the structure due to the applied loading. On the basis of working stress, the area denoting stress energy per unit volume stored in the vessel material is (a-v-w), while for the test stress the area is (a-t-u). These areas are in the ratio of 1 to 4. When the stress energy (a-v-w) is compared with stress energy up to yield point stress on the straight line portion of elastic curve, the ratio of areas is

$$\frac{\text{Area (a-v-w)}}{\text{Area (a-r-s)}} = \frac{1}{6.25}$$

It may, therefore, be deduced that, at the working stress based on factor of safety of 5, for the steel shown in Figure 1, the percent of energy stored at the working stress is only 16 percent of the possible energy that may be stored in the structure at stress of 27,500 psi. corresponding to the yield point of material.

The above analysis should be considered in selecting materials for pressure vessels whose ultimate tensile strength and yield point vary appreciably, since factor of safety alone does not consider the ability of the material to deform with the attendant stress developed during deformation. The capacity of a material to store stress energy may be denoted by a "factor of resilience," f_r. For a given factor of safety selected in the design of a vessel, the material with the lower factor of utilization provides a larger margin of safety.

Considering f_u to denote factor of utilization and S_w design stress

$$f_u = \frac{S_w}{S_y}$$

and s_y = yield point. If the yield point is considered the criterion for failure, and the proportional limit is close to value of yield point, the following relations may be considered where E is the modulus of elasticity of the material and A denotes area under curve in Figure 1.

$$A_{w} = S_w \times S_w/E \times \tfrac{1}{2} = \frac{S_w^2}{2E}$$

and

$$A_{y} = S_y \times S_y/E \times \tfrac{1}{2} = \frac{S_y^2}{2E}$$

then the factor of resilience is,

$$f_r = S_y^2/S_w^2$$

and

$$f_r = \frac{1}{f_u^2}$$

The factor of safety based on the ultimate tensile stress is not generally the best criterion for determining a satisfactory working stress.

A "Factor of Utilization" however based on the consideration of the ability of the structure to store energy without permanent deformation is a more rational factor to consider in selecting a safe design stress.

It compares the economic advantage of designing with alloy steels having relatively high proportional limits and "moduli of resilience" and mild carbon steels with nominal low proportional limits.

Applications of Thermodynamics To Hydrocarbon Processing

PART XXIV—Effect of Pressure on Phase Relationship for Petroleum Fractions

WAYNE C. EDMISTER

Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh

A METHOD of correcting the atmospheric pressure equilibrium flash vaporization curves of petroleum fractions to higher pressures and constructing the phase diagram is presented in this installment along with the empirical correlations of the critical and focal points that are part of this method.

EQUILIBRIUM flash vaporization curves of a petroleum fraction at higher pressures were illustrated on Figures 89 and 90 in Part XXIII (PETROLEUM REFINER, October, 1949) and may be obtained from the atmospheric EFV curve by an empirical method involving the graphical construction of a phase diagram for the fraction on a Cox type (log P vs 1/T) vapor pressure chart.

The procedure and the tools for making these graphical calculations must be developed almost entirely from experimental data. Theoretical considerations are of little value in the development and applications of the empirical correlations involved in this operation.

Salient features of this empirical method of predicting the high pressure phase relations of petroleum fractions have already been discussed in previous installments of this series. The Cox vapor pressure chart was presented as Figure 16 in Part VIII (PETROLEUM REFINER, February, 1948). Mixture phase diagrams and the retrograde condensation phenomena were illustrated by Figure 82 in Part XXII (PETROLEUM REFINER, September, 1949) as was the critical point and its connection with the problem. Figure 90 in Part XXIII introduced the *focal point* concept that will be the key to the method presented for reconstructing phase diagrams for mixtures.

In this installment charts for estimating the focal temperatures and pressures will be presented. The critical point is an intermediate step in this estimation.

The Phase Diagram

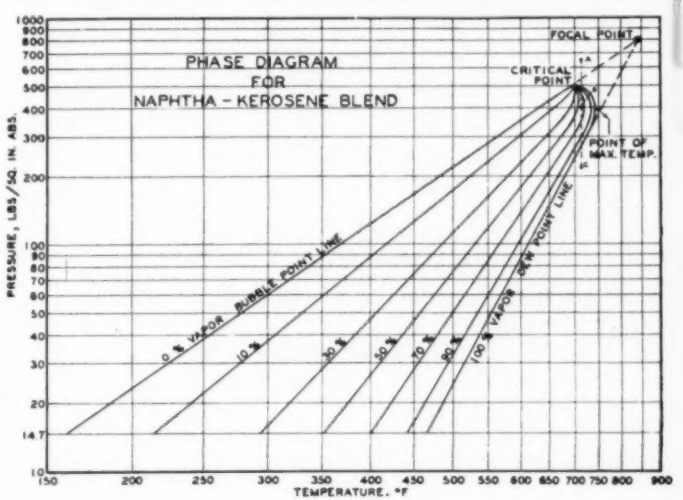
The EFV curves at various pressures for a typical petroleum fraction were given on Figure 89 in Part XXIII. This family of curves illustrates the general trends of the effect of pressure on the equilibrium flash vaporization of petroleum stocks. As pressure is increased, the EFV curves become flatter and less sinuous. When lines of constant precent vaporized are plotted with the logarithm of the absolute pressure and the reciprocal of the absolute temperature as coordinates, the result is the phase diagram shown on Figure 90 (also in Part XXIII). A similar plot for a naphtha-kerosine blend is presented here as Figure 97. This plot shows more of the critical or dome portion of the phase diagram than did Figure 90.

On this type of plot, which is similar to the Cox chart for plotting vapor pressures, the constant quality lines are straight and when extrapolated all intersect at a common focal or critical intersection point. This focal point should not be confused with the focal point on the Cox vapor pressure chart. The Cox focal point is the intersection point of the vapor pressure lines for pure hydrocarbons, whereas, the type of focal point shown on Figure 97 varies according to the properties (average boiling point, boiling range, and gravity) of the stock.

For this particular stock, the focal point is 840° F. and 800 psia. The top of the phase diagram is dome shaped, defining what is commonly called a border curve or a P-T-X diagram. A phase diagram such as Figure 97 may be used to estimate the temperature and phase conditions in fractionating equipment.

Two other important points are indicated on the upper portion of this border curve, the *critical point*, and the *cricondentherm* point or the point of maximum temperature. As indicated on Figure 97, lines of constant percentage vaporized all converge at the critical point, 701° F. and 498 psia. The critical point, which is the point on the border curve where the vapor and liquid phases become continuously identical, is usually near or on the bubble point line as shown, although it may be anywhere between the bubble point and the dew point lines. It will be noted that the point of maximum temperature on the border curve is at 745° F. and 400 psia. The portion of the diagram between 710° F. and 745° F. is the retrograde condensation zone, in which it is possible to

Figure 97. Illustration of Critical Points and Retrograde region. (Plotted from experimental data.)



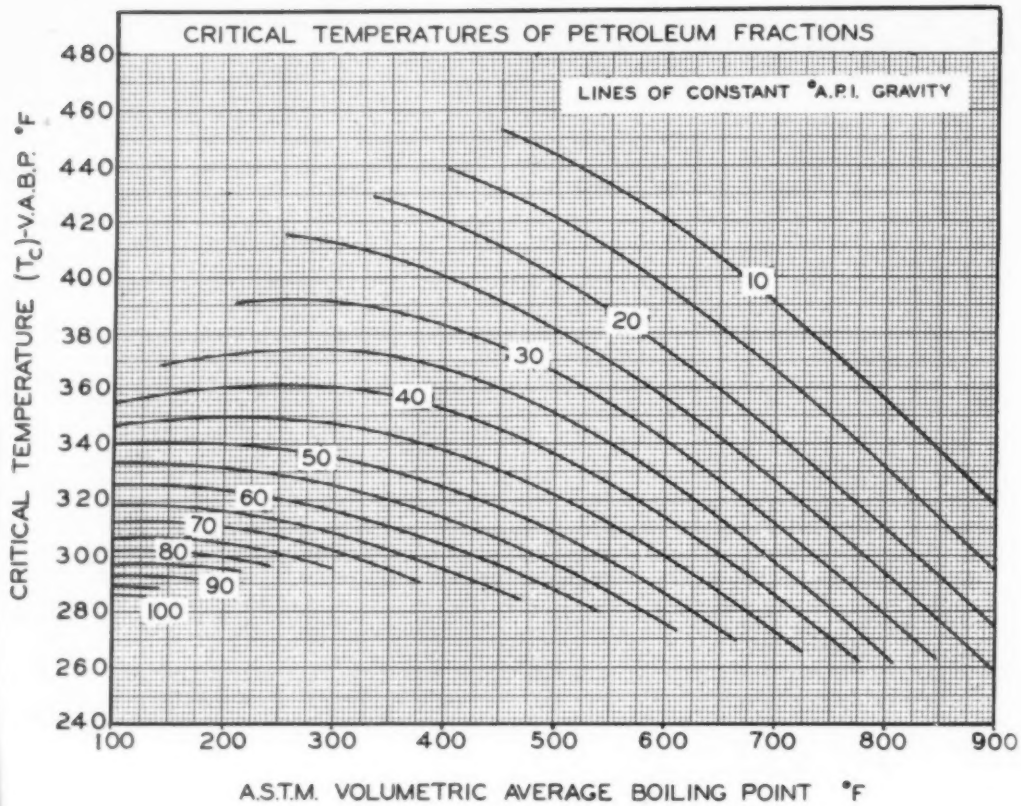


Figure 98.

have liquefaction upon isothermal expansion. In going from vapor at point *A* (650 psia and 715° F.) to vapor at point *C* (210 psia and 715° F.) along the isothermal path ABC, retrograde condensation takes place so that the oil is 30 percent liquefied at point *B*. This phenomenon is common to multicomponent hydrocarbon mixtures and is utilized in the recovery of the heavier fractions contained in high pressures gases from wells producing natural gas.

Pressure Correction Methods

Equilibrium flash vaporization curves at other pressures than atmospheric may be obtained by constructing a temperature vs volume percent vaporized plot, such as Figure 89, or by constructing a phase border diagram, such as Figures 90 and 97. In both methods the starting point would be an EFV curve at atmospheric pressure. In the *flash curve* method, illustrated by Figure 89, the effects of pressure on the 50 percent point and slope of the flash curves must be known so as to permit drawing the flash curve at other pressures from the reference EFV curve. In the *phase diagram* method, illustrated by Figures 89 and 97, correlations for estimating the critical and focal points must be available.

Both of these procedures have been used and both have advantages under different conditions. The estimating of the desired flash curve by empirical methods rather than the construction of a complete phase diagram is feasible and most convenient for low pressure and vacuum vapor-liquid equilibrium calculations. The construction of a phase diagram is necessary at high pressures, particularly in the critical and retrograde region.

In estimating the flash curves of a residual oil under a reduced pressure or vacuum, the atmospheric pressure EFV curve is not the best reference or starting line because the temperatures are too high to permit obtaining an atmospheric ASTM or even extrapolating the EFV curve. Experience has shown that it is not possible to extrapolate higher pressure data to vacuum conditions with any degree of accuracy. This is particularly true if the focal point phase diagram method is used in constructing a phase diagram and the lines of constant percent vaporized are extrapolated on the log P vs 1/T plot. The distance between the focal point and atmospheric pressure is too great to permit extrapolating. Interpolating between these two points is feasible but extrapolation beyond is not practical.

Both Piroomov and Beiswenger[2] and Packie[5] recommended *flash curve* methods of obtaining the vaporization characteristics at higher pressures, in which the flash curve is displaced parallel to itself on temperature vs volume percent vaporized scale to a higher pressure mid-point determined from a Cox vapor pressure chart. This method involves the assumption that the slopes of the flash curves of a given stock are the same at all pressures, which assuption is justified for small pressure changes but is not generally applicable and so should not be used in making high pressure EFV curve estima-

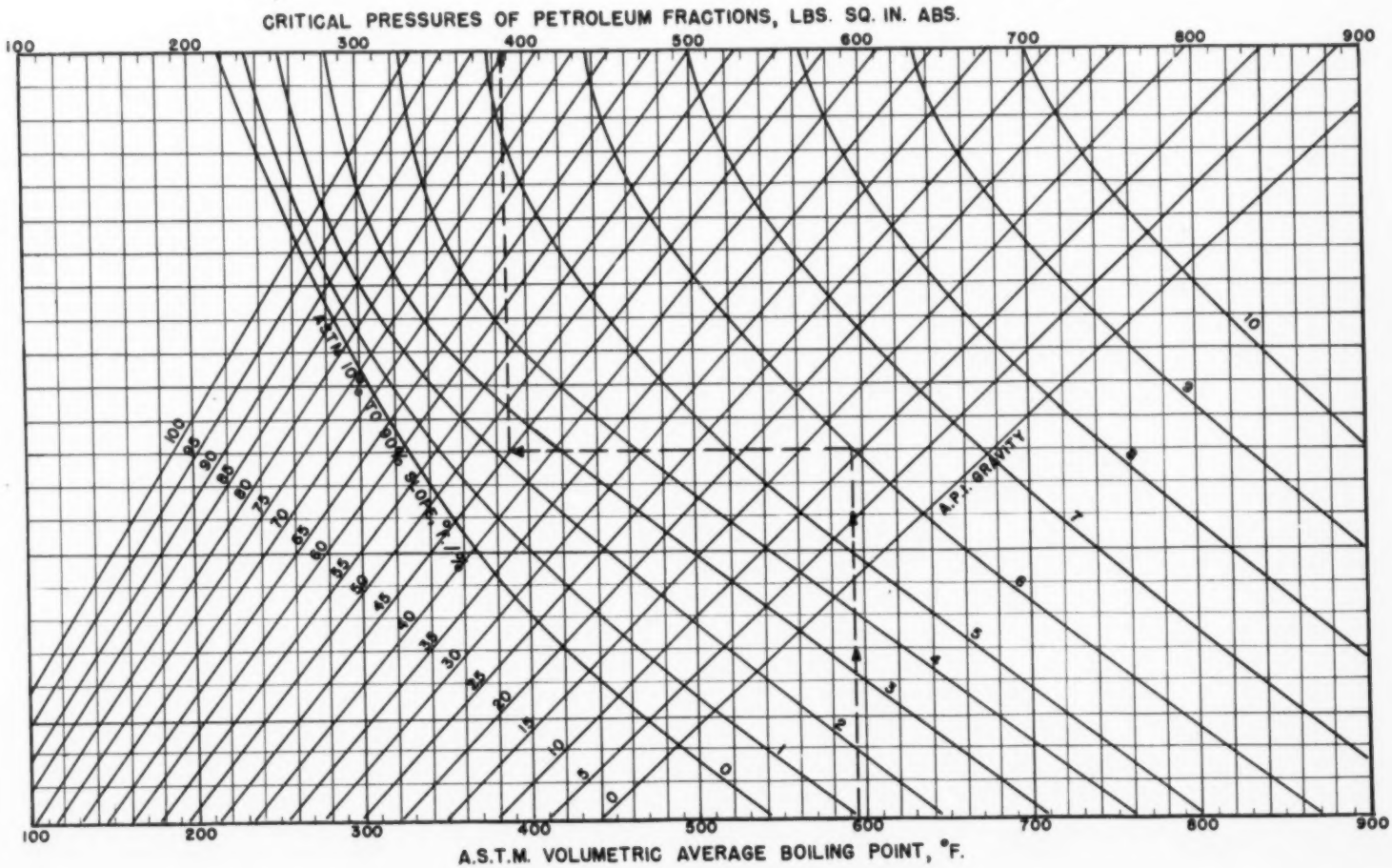

CRITICAL PRESSURES OF PETROLEUM FRACTIONS, LBS. SQ. IN. ABS.
100
200
300
400
500
600
700
800
900
A.S.T.M. 10% TO 90%
A.P.I. GRADIENT
A.S.T.M. VOLUMETRIC AVERAGE BOILING POINT, °F.

Figure 99.

tions. An empirical method was proposed by Katz and Brown[5] for estimating flash curve slopes, taking into consideration the change slope with increasing pressure. Katz and Brown suggested that the slopes of the higher pressure flash curves be obtained from the atmospheric pressure EFV vs ASTM correlation by using an equivalent (i.e. corrected to the higher pressure) ASTM slope, found from a plot involving the reduced pressure and the atmospheric pressure ASTM. This plot gave zero as the limiting value of the slopes of the equivalent ASTM at unity reduced pressure. It also gave the atmospheric pressure ASTM slopes at zero reduced pressure as the limiting values of the slope of the equivalent ASTM. The zero slope limit would exist at the focal pressure only, so the reduced pressure should be based on the focal pressure rather than the critical pressure.

The vapor presure chart method of estimating the higher pressure flash curve 50 percent point is only approximately correct for higher pressure differences, while entirely satisfactory for low and moderate pressure increases.

This is because the vapor pressure curves of different types of hydrocarbons have different slopes, so that the loci of the 50 percent points of the EFV curves at different pressures might follow the vapor pressure curves of paraffin hydrocarbons for some stocks but have flatter or steeper slopes for other stocks.

While proposed for pressures higher than atmospheric, the *flash curve* method suggested by Piroomov and Beiswenger and by Packie appears to have better possibilities for estimating vaporization characteristics of petroleum fractions under vacuum conditions, where the construction of a complete phase diagram is not necessary. It would seem logical that this method could be applied to pressure conditions and to stocks encountered in two-stage crude distillation units. This would include various whole and reduced crudes and pressures from about four atmospheres down to 100 mm. of mercury. The development of such a correlation would require more data than are currently available. A successful correlation might involve developing and using two reference flash curve correlations, one at atmospheric pressure and one at some reduced pressure, such as 100 mm.

The *phase diagram* method has been more extensively used for high pressure EFV calculations. In 1933, three independent publications[5,10,12] noted the existence and importance of the focal point of the phase diagram. At that time there was no actual data at higher pressures except Bahlke's and Kay's[1] border curves for two petroleum distillates, on which there were no atmospheric pressure EFV data. Accordingly, these early suggestions could not be completely developed, yet these 1933 speculations and suggestions were amazingly close to the facts and provided estimation methods for use until more reliable correlations could be developed. These early contributions will be briefly reviewed.

Ragatz, McCartney, and Haylett[10] observed that as the pressure is increased the initial and final vaporization temperatures (bubble and dew points) of a hydrocarbon mixture converge, and finally intersect each other at a point which they called the critical intersection point.

Watson and Nelson[12] concluded, from a study of a number of petroleum stocks, that a line drawn through the molal average boiling point on a Cox type vapor pressure chart with the same slope as the nearest hydrocarbon vapor pressure line will pass through the critical intersection point. They further observed that, measured along the molal average boiling line, the distance from the critical intersection point to the critical temperature was one-fifth the distance from the critical temperature to the temperature at atmospheric pressure.

Katz and Brown[5] illustrated the graphical construction of the phase diagram on a Brown and Coats (see Part VIII) type of vapor pressure chart. This example involved locating the focal point on an equivalent pure component vapor pressure line in the same manner as suggested by Watson and Nelson.

Edmister and Pollock[3] selected the focal point method for predicting high-pressure flash curves. These authors further decided to relate the focal point with the critical point in order to utilize the critical data available and partially to make up for the limited amount of high pressure phase diagram data available for the determination of focal points.

Phase Diagram Data

In order to provide experimental data for the construction of phase diagrams and for the determination of focal points, Edmister, Reidel, and Merwin[4] obtained flash curves of three petroleum fractions at four pressures (0, 50, 100, and 200 psig.). Also Edmister and Pollock[3] obtained the same kind of data on six petroleum fractions. These two experimental programs were carried out in different but nearby laboratories at approximately the same time and with similar apparatus. As mentioned in the previous installment, the article first completed was the last to be published. For this reason the Edmister-Pollock focal point correlations were developed from the six new phase diagrams plus the two of Bahlke and Kay but without the Edmister-Reidel-Merwin data. It was subsequently checked against the latter data.

The apparatus used in these higher pressure runs was described in these two articles. A former thermal cracking pilot plant was used by Edmister and Pollock. A description of this experimental apparatus and work from the article by Edmister and Pollock[3] follows:

This apparatus consists of charge tanks, a Hills-McCanna charge pump, three heating coils immersed in gas fired lead pots, an insulated and electrically heated flash chamber equipped with a Jurgeson liquid level gauge, overhead product condensing, separating and collecting equipment, and bottoms cooling and collecting equipment. Temperature indicating points were located at the outlet of the last heating coil and at the top and bottom of the flash chamber. The temperatures at all three points were maintained the same by means of four electrical resistance heaters spaced along the flash chamber and controlled separately by means of rheostats in the circuits. The flash chamber and all auxiliary lines were well insulated. The pressure and liquid level were maintained constant by manually operated valves. The liquid depth was about 14 inches during the runs. Both vapor and liquid products were eliminated during all runs in order to be certain that equilibrium conditions existed. For this reason it was not possible to determine the bubble or dew points experimentally by direct measurements, although they were closely approached in the experimental work.

In order to determine the characteristics of the apparatus with respect to the establishment of equilibrium and absence of entrainment, a series of experiments were carried out with a single charge stock under constant operating conditions. Runs were made at feed rates of one, four, and eight gallons per hour. Results at the several feed rates agreed within experimental error and it was concluded that an equilibrium separation of vapor and liquid was established in the apparatus. The normal feed rate during subsequent runs was four gallons per hour because there was a tendency for the flash chamber to coke up in the liquid zone for the lowest charge rate and because the overhead condensing equipment was of inadequate capacity to

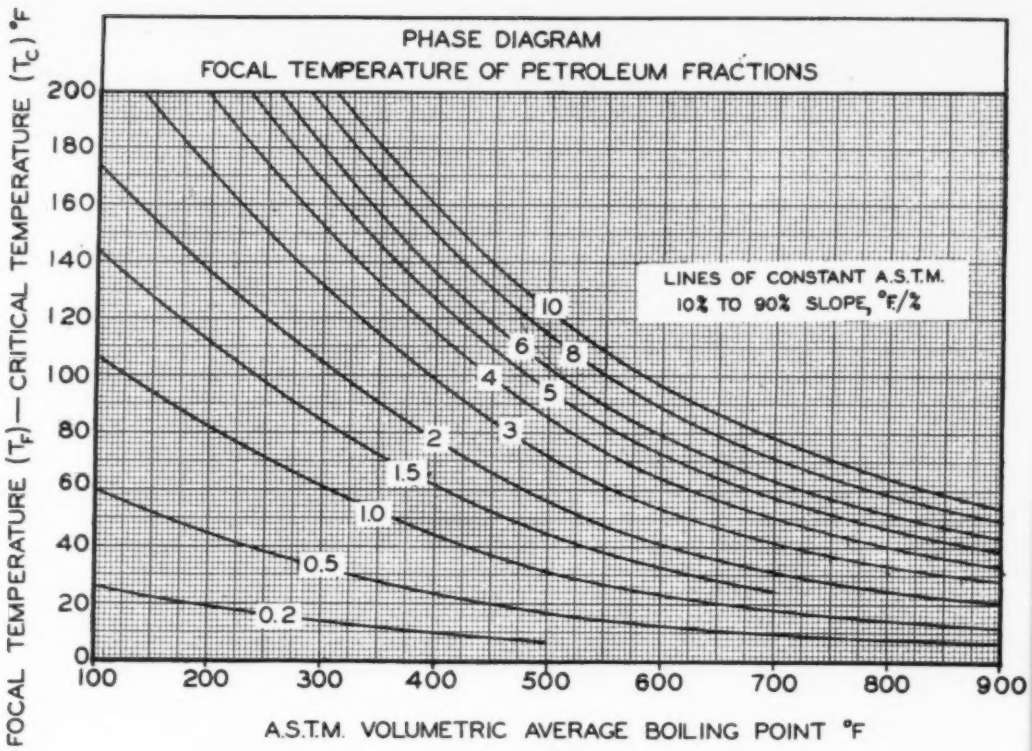


Figure 100.

maintain the highest charge rate.

The apparatus was run by process laboratory operators working in three eight-hour shifts under technical supervision. The operating procedure was the same as for similar pilot plant equipment. About eight to ten hours were required to bring the unit up to any desired flashing temperature or to change temperatures. After equilibrium conditions, indicated by constant temperature and pressure conditions and by constancy in the gravity of the liquid product, were established, operation was maintained steady for three hours while composite samples were taken and periodic temperature and pressure readings made.

Because of the long time required to change the temperature, the temperature was maintained constant for a series of determinations at different pressures. During the test all streams were measured and liquid levels maintained constant so that an accurate material balance could be made for each run.

The equilibrium flash vaporization data obtained during this experimental work was given in the original article. Flashing conditions, percent vaporized, and inspections on the products are included in these tables. In the cases where gas was produced, this is also indicated in the table. In some instances the gas was entrained in the charge while in others it was formed by cracking, which was usually very slight, nevertheless it invalidated the results for that run. The correlations of the atmospheric pressure EFV data were presented in Part XXIII. In this installment the effect of pressure will be correlated. This will be done by correlating the critical point first and then relating the focal point to the critical point.

Critical Point

In connection with the discussion of convergence correction to vapor-liquid equilibrium ratio (Part XXII, PETROLEUM REFINER, September, 1948) the critical point of hydrocarbon mixtures was discussed and methods of estimating the temperature and pressure conditions at the critical point were presented. The focal point method developed by Edmister and Pollock for constructing phase diagrams of petroleum fractions included correlations for estimating the critical pressure and temperature. These correlations are presented here as Figures 98 and 99.

The critical point is an important point on the phase diagram because it defines the conditions above which two phases cannot exist. Experimental critical point data are available in the literature.[1,2,7,11,14] A total of 201 observed critical temperatures and 155 critical pressures of petroleum fractions were available for this study.

These data were used in developing the empirical critical point correlations presented here as Figures 98 and 99. Critical temperatures are correlated as a function of the API gravity and the ASTM volumetric average boiling point (vabp.), which is the average of the 10, 30, 50, 70, and 90 percent points. In correlating critical pressures it was necessary to include the ASTM 10-90 percent slope in addition to the API gravity and vabp. variables. Critical points for the pure hydrocarbons of various types, as well as for petroleum fractions of different characteristics, were used in developing these correlations. The average deviations of the predicted critical points from the observed critical points are ±4.5° F. for the critical tempera-

ture and ±12 psi. for the critical pressure.

Focal Point

In describing the phase diagram, the significance of the focal point was emphasized and the previous work of others was reported. Edmister and Pollock correlated the focal point with reference to the critical point. These charts are given as Figures 100 and 101.

Using all the available data, which included the equilibrium flash vaporization curve data reported in this paper, the border curve data reported by Bahlke and Kay,[1] and the border curves by Kay,[6] the method of predicting the focal point given in Figures 100 and 101, was developed. These focal point correlations have been tied to the critical point for two reasons: (a) the critical point must fall within the fan shaped family of straight constant quality lines drawn through the focal point and the atmospheric EFV curve points, and (b) the correlation of the difference in the focal and critical points (a residual quantity) is more accurate than the direct correlation of the focal point because of the large number of observations that were used in developing the critical point correlations and the small number of focal point observations available. The focal points were determined graphically for each stock, on which equilibrium flash vaporization or border curve data were available at various pressures, by plotting the data on the Cox type of chart, Figure 97. The accuracy of this method for predicting the effect of pressure on the EFV is ±3° F. at 50 psig. and ±5° F. at 100 psig.

Example

This method will be illustrated by completing the phase diagram for the stabilized gasoline used to illustrate the atmospheric pressure flash curve estimation in Part XXIII.

The critical point is determined by means of the ASTM 10-90 percent slope, which is 2.8° F. percent off, and the gravity. The critical temperature is found to be 553° F. 234 + 319 = 553° F.) from Figure 98 and the critical pressure is found to be 555 psia. from Figure 99. The differences between the critical point and focal point temperatures and pressure were found to be 151° F. and 477 psia. from Figures 100 and 101. The focal temperature and pressure are determined by adding to the critical point differences obtained from Figures 100 and 101 as follows.

$$T_F = 553 + 151 = 704° \text{ F.}$$
$$P_F = 555 + 477 = 1032 \text{ psia.}$$

The atmospheric EFV curve from Part XXIII for this sample plus the above estimated critical and focal point values are plotted on Figure 102 and the phase diagram for this stabilized gasoline is graphically constructed. If this fraction were the bottom product of a stabilizer operating at 325 psia., the bottom temperature of the tower could be determined from

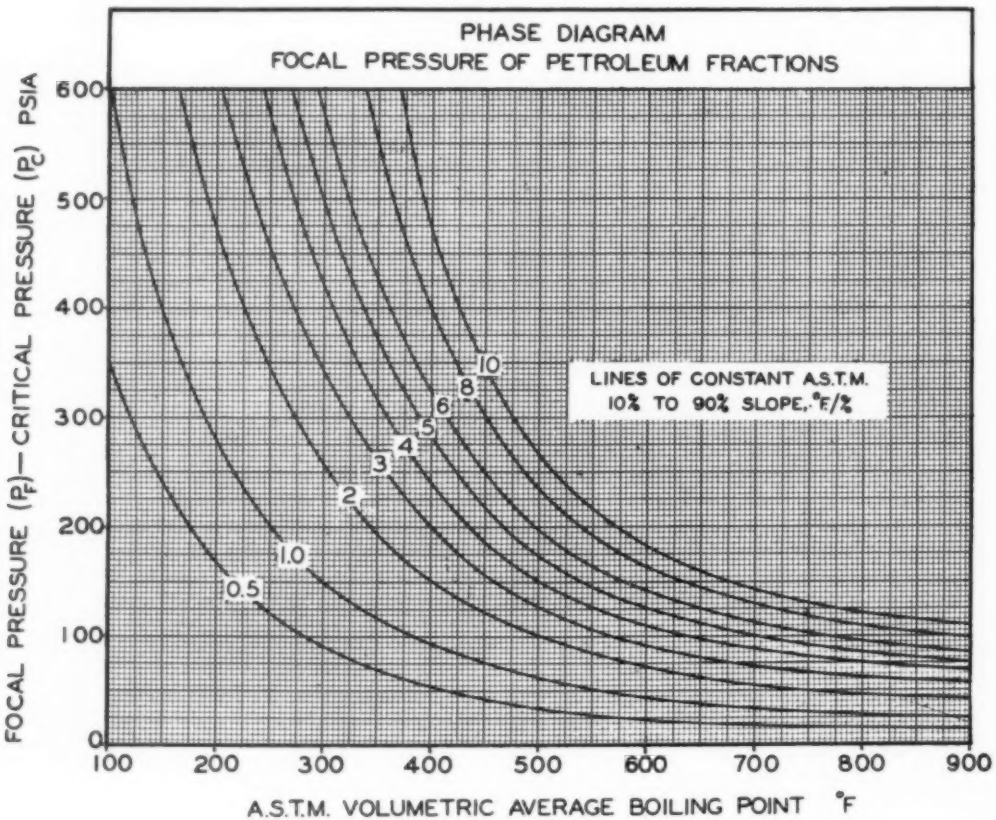


Figure 101.

the bubble point line of Figure 102. Such a reading gives 450° F. If this gasoline were the overhead from a rerun tower operating at 120 psia., the top temperature of the tower could be estimated from the dew point line of Figure 102. Such a reading gives 450° F. From Figure 102 the percent vaporized at any condition in an equilibrium flashing operation can also be estimated. At 55 psia. and 300° F., 38 percent will be vaporized.

In the next installment, to appear in an early issue, correlations for estimating the properties of the equilibrium vapor and liquid will be presented.

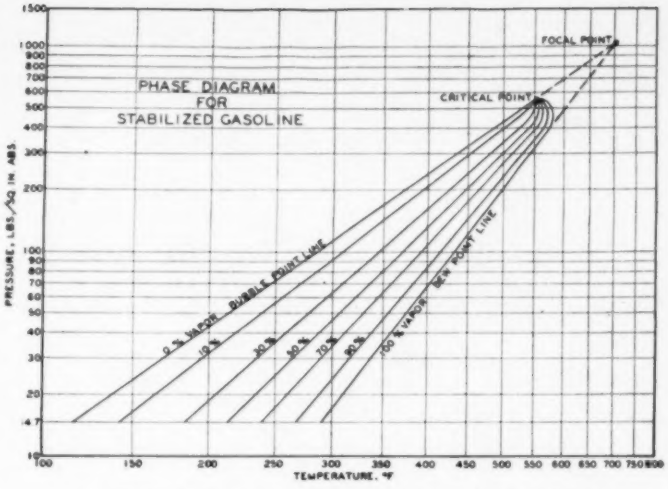


Figure 102. Plot of Phase Diagram for Example Illustrating Calculation Method.

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(End of Part XXIV. Part XXV will appear in an early number.)

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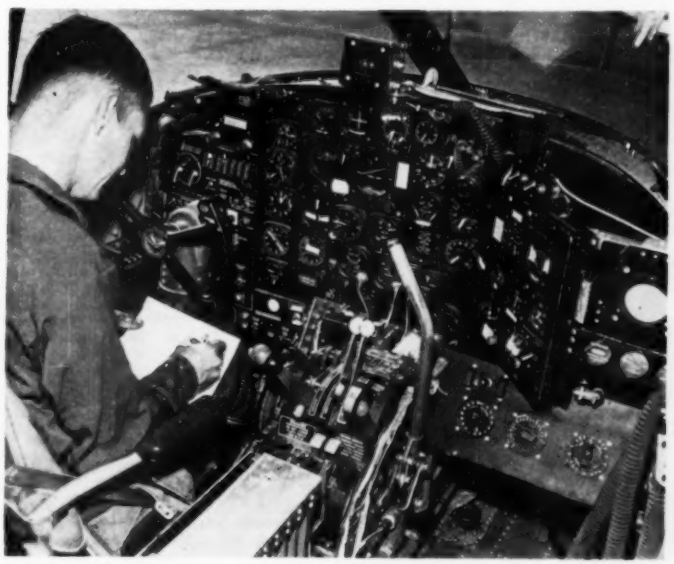
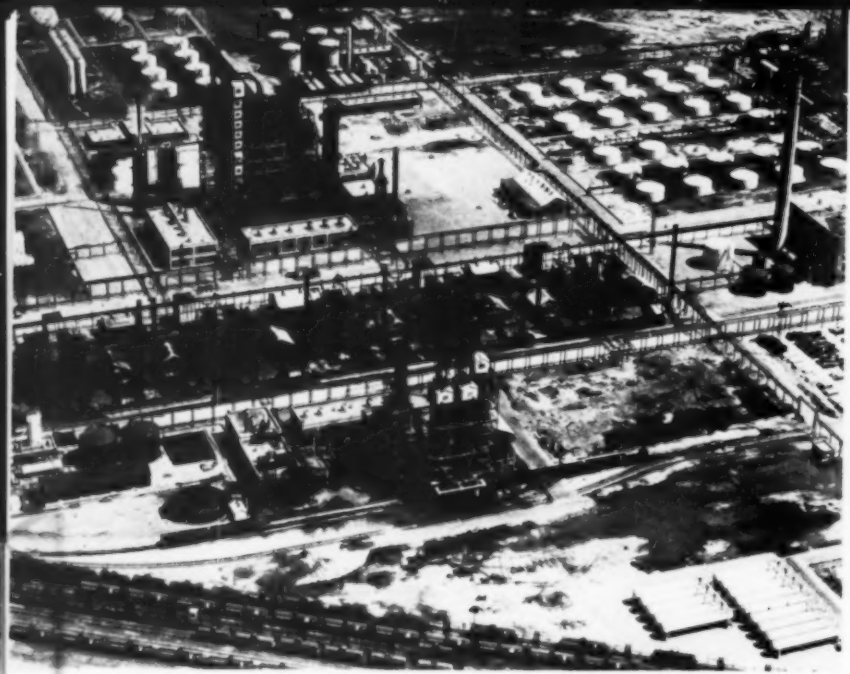
Jet Fuels and Lubricants Being Studied



Shell Oil Company has acquired one of the Air Force's jet-equipped research planes to study performance of jet fuels and lubricants in actual flight operation. This is the first such plane to be operated by any oil company. Now in operation in Oakland, Calif., the twin engine B-26 type bomber has a jet engine specially mounted in the fuselage as well as reciprocating engines in the wings. Designated as XB-26F because of its experimental nature, it has elaborate analytical and recording instruments in the cockpit permitting tests, during actual flight, of fuels and lubricants for both types of engines. The center panel holds conventional twin engine instruments. Jet engine instruments are right center, and at far right is an engine-analyzer oxcilloscope with controls mounted below.

Four men are permanently assigned to the plane; a research engineer, a pilot, a mechanic, and an instrument man. Over-all direction of research rests with a six-man steering committee headed by J. H. Doolittle, vice president of Shell Oil Company, and including members of the company's technical departments.



This aerial photograph of Cities Service Oil Company's East Chicago plant shows the major processing units that formed the modernization program. Bottom center is the delayed coking unit, with the old thermal coking units just back of it. Beyond the old coking units and to the left is the new catalytic cracking unit, with the treating plant at the top center. A part of the alkylation unit is shown top right.

Cities Service Completes $20 Million Modernization Job At East Chicago, Ind.

CITIES Service Oil Co. (Delaware) has completed at its East Chicago, Ind., refinery a modernization and expansion program that cost approximately $20 million, and includes a fluid catalytic cracking unit with gas recovery plant and a delayed coking unit.

The fluid catalytic cracking unit is of the latest design, with a capacity for 14,760 barrels of feed stock daily and a gas-oil conversion capacity of 10,300 barrels daily. Catalyst circulation is rated at 20 tons per minute. Coke burning capacity is listed at 15,000 pounds per hour. The unit's steam generation capacity is 110,000 pounds per hour.

The fractionating tower for the catalytic cracker is 120 feet high by 16 feet in diameter, while the reactor vessel is 50 feet high by 21 feet in diameter. The regenerator is 35 by 36.5 feet.

The delayed coking unit provides relief to the plant's skyline with towering derricks atop the 80-foot high coke drums. Seventeen and a half feet in diameter, these two coke drums are said to be the largest in use by any U. S. refiner. Each of these drums has a 326-ton capacity.

Minor processing units included in the program include revamped gasoline treating, light ends recovery, gas purification units and a revamped thermal recovery unit.

Auxiliary projects include modernization of the refinery's water and sewer system, installation of equipment for cleaning effluent water, increases in boiler-plant capacity, the construction of several new buildings and additional products and crude oil storage.

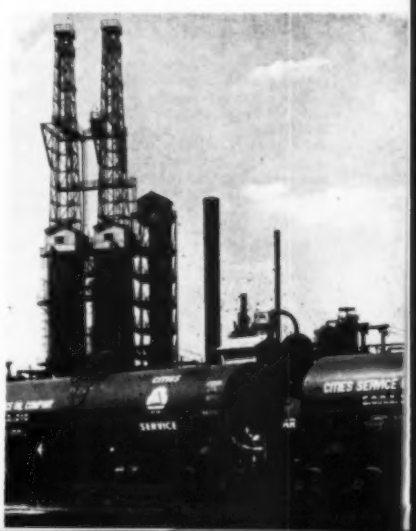
Engineering construction and design of the program was by The M. W. Kellogg Company.

Completed earlier this year, the technical service laboratory at the East Chicago refinery will serve as the testing point for product quality control during manufacture and will develop test standards for refinery laboratory use.

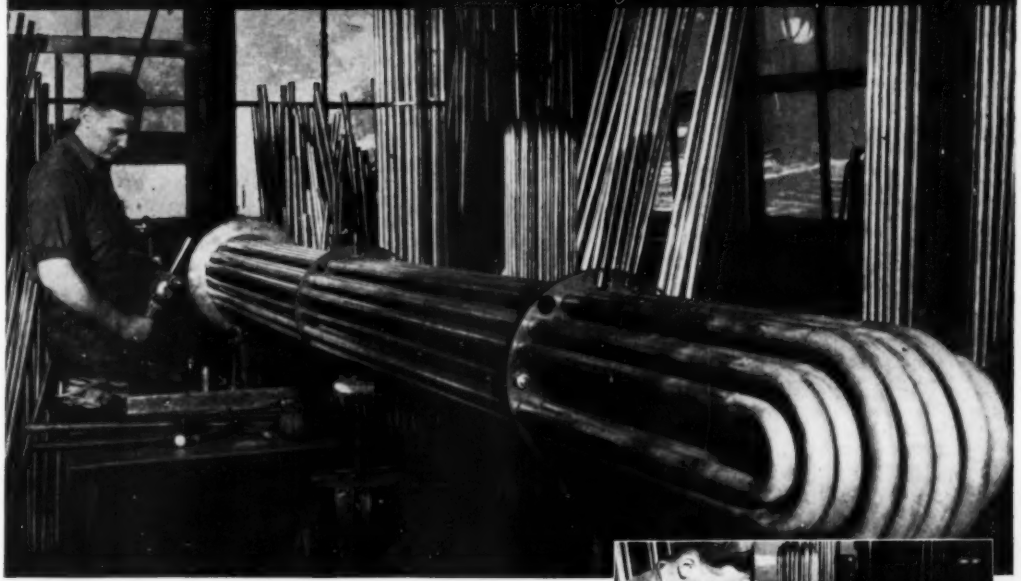
The East Chicago refinery was built in 1929 and 1930. Intervening years were marked by other modernization programs, climaxed by the addition of an alkylation and isomerization plant as a war-time expedient.

Left—Bubble Tower at the East Chicago Refinery of Cities Service Oil Company.

One of the major processing units included in Cities Service's East Chicago modernization program included the delayed coking unit, shown here at the left. Each of the two coke drums has a capacity of 326 tons of coke.



REVERE COPPER TUBE
of Special Bending Temper . . .



. . . saves bending time, enables WESTERN BLOWER CO. to produce neater, more uniform tube bundles.

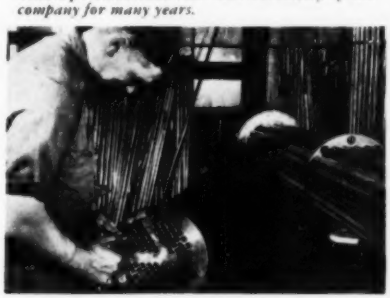
During the past nine years, Western Blower Co., of Seattle, Wash., has used hundreds of thousands of feet of ⅝" and 1" O.D. Revere Seamless Copper Tube of special bending temper, with .049" wall.

They tell us that in working with this Revere Tube they are able to make large and small radius bends without the slightest difficulty and without heat treating, excepting the smallest 1" radius. This not only saves bending time but, enables them to turn out a better appearing tube bundle . . . an important item with Western Blower as many of their bundles are sold without tanks.

In addition to the above, this company has also used tens of thousands of feet of Revere Cupro-Nickel Tube in heaters where salt water was a problem. For this metal, which is one of the most corrosion-resistant of the copper nickel alloys, can withstand high operating temperatures and is not subject to dezincification.

Have you investigated the Revere metals to see how they might help you with your tube problems? Why not have Revere put the knowledge and experience, gained through years of helping others, to work for you? Call the nearest Revere office today.

EXPANDING THE TUBE ENDS outside the header of one of the U-bend heat exchangers being turned out by the WESTERN BLOWER CO. Revere products have been used exclusively by this company for many years.



FLARING THE TUBE ENDS over the header. These coils, made of Revere Seamless Copper Tube, of Special Bending Temper, are used in tanks for domestic hot water, in side arm heaters, condensate coolers and converters.

REVERE

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REFINER AUTHORS and Other Personalities

The Busy Trio Writes About Plant

"Stepwise Expansion Program Keeps Plant on Stream," page 123, by three Petrol Refining, Inc., men, V. E. Smith, vice president in charge of refining operations, D. E. Fuller, superintendent of refinery operations, and B. F. Bottenfield, process engineer, is quite obviously the success story of how to put a refinery on stream and keep it there, despite some unusual obstacles. The moral of the story, in addition to the description of how to adapt a wartime fixed-bed gas-oil catalytic cracking unit to peace-time operation on whole crude oil, might well be that there is no substitute for experience and ingenuity in the refinery.

V. E. Smith, a man who does lots of listening, was born in Olean, N. Y., in 1889, but by the time he was eleven years old, the family had settled in East Texas. Here he completed high school and two years study of medicine which he had to give up in order to augment the family income. He went to work on the railroad, became a telegraph operator and later mastered Marconi wireless. His first contact with the oil industry was a job as oiler-telegrapher with the Texas Pipe Line Company at Electra, Texas, in 1914.

His work as a ditch digger, a pipeliner, stationary engineer, driller, boiler fireman, etc., caused him to switch to refining and he worked in refineries at Burkburnett, Electra, Wichita Falls, Olney, and Magargel, Texas, in several different kinds of jobs that ranged up to operating assistant superintendent, and construction superintendent.

In 1936, Smith came to Texas City. As assistant superintendent for Southport Petroleum Company, he assisted in design of the 100-octane refinery built by Defense Plant Corporation, adjacent to the Southport plant and later was in charge of the facilities. He closed the 100-octane plant within two weeks after V-J day and continued the operation of the other facilities of Southport until June, 1947, when he joined his present company.

Smith doesn't have much time for hobbies, but he thoroughly enjoys fishing, golf, baseball, bowling, and reading. He has a son, three daughters, one granddaughter and five grandsons.

D. E. Fuller and his people moved out of Beaver County, Oklahoma, three years after he was born in October, 1907. When he was six years old, the Fullers were at home on a Kansas wheat farm. By the time he was graduated from high school, young Fuller was attracted to geology and worked his way through the University of Oklahoma, 1924-29, majoring in that subject. After graduation, he worked as a geologist for Gulf Refining Company in Mississippi, Alabama, Georgia, and Florida, but in 1932 moved to Kansas City and went to work with a power plant contractor. A year later he became a laboratory tester for The Pure Oil Company at Beaumont, Texas, and later transferred to Magnolia Petroleum Company. During the next 14 years, Fuller was laboratory tester, fireman, gas plant operator, combination topping, visbreaker, thermal cracking, and Houdry cracking plant operator. He was a special operator in starting up new catalytic cracking equipment and traveled to eastern refineries to assist in starting up new equipment. At the time he left Magnolia in 1947 for Petrol at Texas City, he was senior process engineer in charge of Houdry catalytic cracking.

D. E. Fuller

Fuller and Mrs. Fuller have three sons, which accounts for much of his interest in fishing and hunting and golfing.

Baird F. Bottenfield is a native of Gary, Ind., (1920). After moving to Birmingham, Ala., in 1937, Bottenfield decided on chemical engineering and in 1942 was graduated from Georgia Institute of Technology.

He saw duty with the Chemical Warfare Service at the Pine Bluff Arsenal, where he was supervisor over various units engaged in the manufacture and filling of chemical munitions (incendiary bombs and grenades, white phosphorous bombs and grenades, smoke shells and poison gas bombs and shells).

After the war he joined Magnolia at Beaumont and worked as junior process engineer and process engineer on gasoline rerun, light hydrocarbon and gas concentration systems. He joined Petrol Refining, Inc., at Texas City in January, 1948.

Bottenfield likes his sports—basketball, bowling, softball, golf, etc.—but has found that he and Mrs. Bottenfield are quite busy with two sons, Larry, 4 years, and Alan, who arrived in August.

California Pair Contributes Article

Beginning on page 133 in this issue is an article entitled, "Rich Oil Stabilization" written by Saul Goldblatt, process engineer, and H. M. Nelly, Jr., vice president, of Refinery Maintenance Company, Inc., in Compton, Calif. These engineers present an interesting and informative discussion on the separation of methane and ethane from the rich oil stream with retention of propane and heavier components in the design of natural gasoline plants. A new system is described for this operation.

Saul Goldblatt took his technical

V. E. Smith

Baird F. Bottenfield

H. M. Nelly, Jr.

S. Goldblatt

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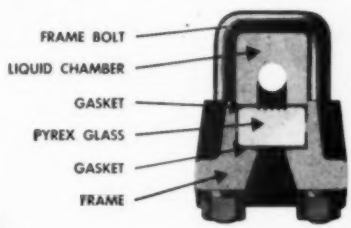
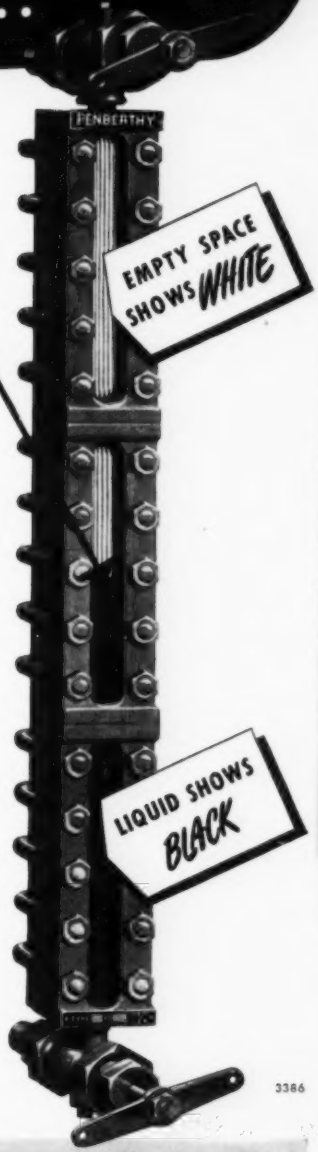
Penberthy Drop Forged Steel Reflex Gages are available in whatever lengths required and for various liquids. They are also fabricated to customer's specifications from special alloys to meet unusual corrosive and temperature conditions. There is a Penberthy Gage of superior quality for every liquid level gage requirement.





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H. J. Multer

D. H. Imhoff

Clyde Berg

R. G. Fairfield

Walter G. Whitman

training at the University of California at Los Angeles and the University of Southern California. He has received a B.A. degree in chemistry and B.E. and M.S. degrees in chemical engineering. He worked four years in general engineering at Tidewater Associated Oil Company at Avon before joining Refinery Maintenance in 1947 as process engineer. He has been specializing in the design of gasoline plants since then. Goldblatt's principal hobby is making 16-mm. movies.

H. M. Nelly, Jr., is a 1928 graduate of the University of Michigan in chemical engineering. In 1930 he received his master's degree from Massachusetts Institute of Technology, also in chemical engineering. For eight years following graduation, he worked for The M. W. Kellogg Company, then he joined J. F. Pritchard Company as manager of their petroleum division. In 1947 he joined Refinery Maintenance Company as vice president.

MIT Professor On Liquid Fuels

Professor Walter G. Whitman, head of the department of chemical engineering, Massachusetts Institute of Technology, and author of "Liquid Fuel Supplies and National Security" (page 97), is an MIT grad, who for eight years (1926-34) served on the research staff of Standard Oil Company (Indiana). When, in 1934, he was named to his present post, he also became director of the School of Chemical Engineering Practice, which gave him administration over all practice schools until 1946. He has continued since that date in charge of these schools which include the Graduate Engineering Practice School established by the Atomic Energy Commission in 1948 at Oak Ridge, Tenn.

During World War II he was in Washington with the War Production Board where he was in charge of all base chemicals. He served as chairman of the sub-committee on aircraft fuels and lubricants, on a special OSRD committee and many other groups seeking to aid the services along technical lines.

Dr. Whitman is widely known for his scientific contributions in the fields of corrosion and the absorption of gases by liquids, being the first to appreciate the extent to which the results are controlled by processes of diffusion. These developments have for the first time placed the problems of design on a sound engineering basis and have contributed largely to increased efficiency in operation in various industries, such as the recovery of gasoline from natural gas, the manufacture of heavy chemicals, etc.

Hypersorption From Union Oil Quartet

"The Hypersorption Process for Separation of Gases and Vapors," which starts on page 113, is presented by four Union Oilers from California—Berg, Imhoff, Fairfield, and Multer. Their article is a presentation of data and application of the hypersorption process, which has attracted wide interest.

Clyde Berg is supervisor in charge of process development for Union Oil Company. He was graduated from the University of Minnesota in 1936. During his postgraduate work he instructed in the chemical engineering department and was awarded the Hormel Research Fellowship. He obtained his Ph.D. in 1940 and entered the process design and development group, has been supervisor since 1942.

Under his supervision, a wide range of processes have been developed. He has published many articles on hypersorption, retorting, and refining shale oil, etc. Berg serves as program chairman of the local section of the AIChE. As a change from process work, he goes in for sailboat racing with swimming and golf reserved for poor sailing days.

D. H. Imhoff was graduated in 1943 from Washington State College with highest honors in chemical engineering and after college entered the process development group of Union Oil. He has been associated with development of the hypersorption process for the past five years. Also, he was active in the design of various commercial plants built recently. He has been engaged in development on production of various chemicals, high-temperature cracking studies, sulfur removal, etc. His outside activities included golf and fishing—once. The Imhoffs have a very young daughter.

R. G. Fairfield, a chemical engineering graduate of Oregon State College, 1941, joined Union after graduation and since has worked in the research department at Wilmington, Calif., in pilot plant investigations concerned with catalytic processes, desulfurization, oil absorption, and hypersorption for five years. The past three years he has been engaged in process development studies and has assisted in the design and start-up of commercial hypersorption units. Recently he was transferred to the Union refinery at Oleum, Calif., as process supervisor. He has co-authored papers on catalytic desulfurization and ethylene recovery. His spare time is absorbed by his family—wife and three boys. His badminton game is competitive and his golf game social, but they are his major hobbies.

Hugh J. Multer is a 1916 graduate of the University of Southern California. He served in the Chemical Warfare Service in World War I and after the war, was a research chemist in the sugar and cyanide industries for a number of years. He joined Union in 1928, serving in the gas and field departments. Later he was transferred to the research department and then the process development department. He has been associated with the development of a continuous process for the recovery of oil from shale. He assisted in the pilot plant investigation and plant start-up of the hypersorption process. Multer's two granddaughters are his latest and most fascinating hobby.

Four PR Authors Termed "Repeaters"

Four of the authors in this issue of PETROLEUM REFINER are "old heads" insofar as these columns are concerned:

"Mitro Penetration Test for Waxes," page 110, is by A. Kinsel and J. Phillips, who also co-authored articles in the December, 1948, and April, 1949 issues of P. R. Kinsel, a native of Czechoslovakia, is a graduate of the Polytechnic of Prague (1910) and has been associated with refineries in Mexico, South America, Europe and Russia as well as in this country. Almost as varied are the non-professional interests of Phillips, including golf, a classical records collection, reading mystery stories, swimming, and playing bridge.

The other pair of veterans is R. R. Maccary and R. F. Fey who co-authored "Factor of Safety vs. Factor of Utilization," page 147 as well as an article in the July issue of PR. Maccary is a former designer of interior decorations, having since turned however, as a mechanical engineer, to the geometry and design of plant equipment. Fey, a civil engineer, also creatively inclined, has estimated and designed steel plate structures for units ranging from elevated storage tanks to wind tunnels.

design for growth

The construction of both of these 3-stage crude distillation units for the Humble Oil & Refining Company followed the same basic design. The design was "right" in 1940,— it is still "right" in 1949.

Such "design correctness" saves time and money. It is the product of experience,— Foster Wheeler's long experience in the building of over 500 process units for refiners in all parts of the world.

It is available to any refiner planning expansion or rehabilitation of refinery processing equipment.

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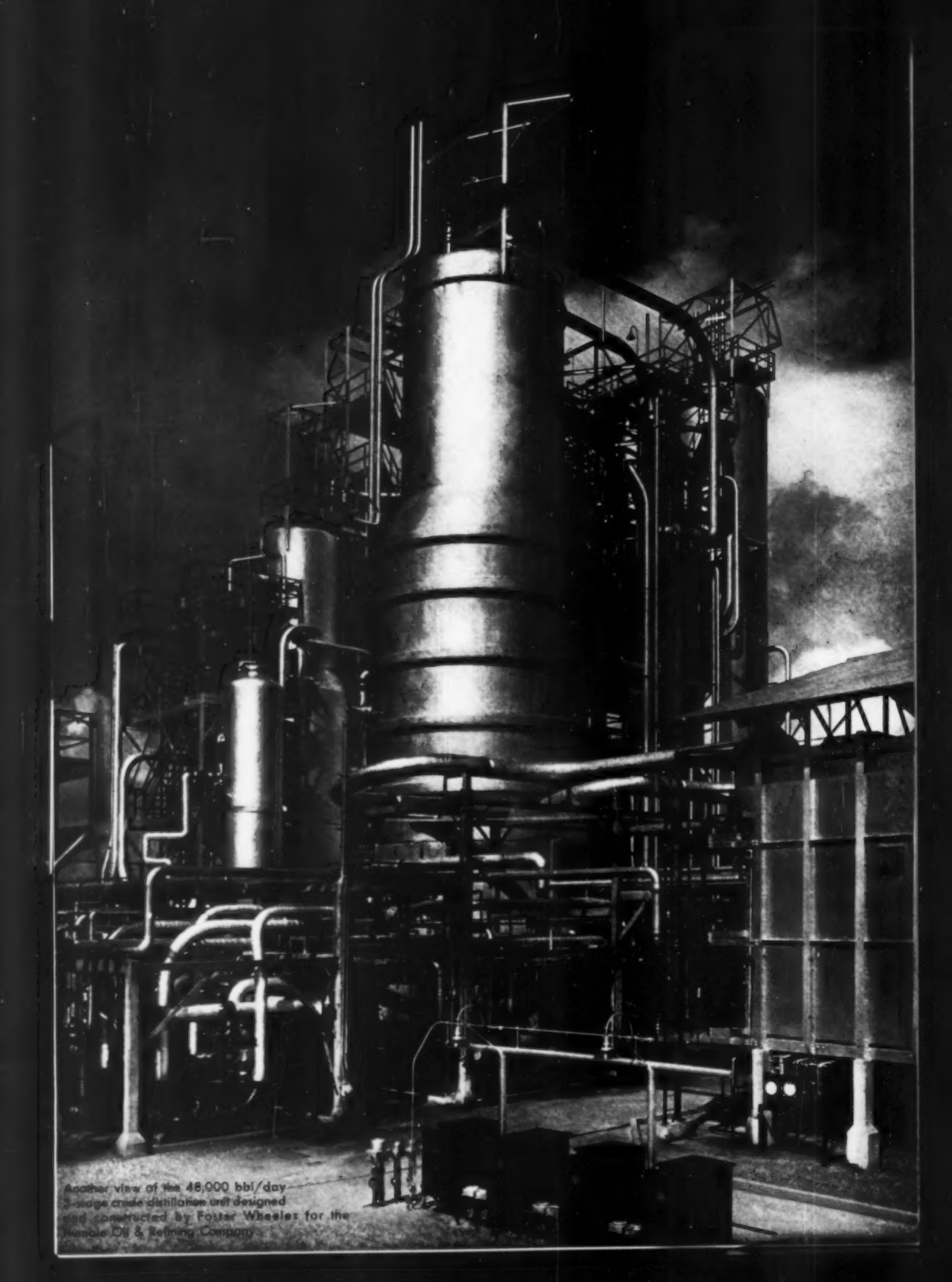


Another view of the 48,000 bbl/day 3-stage crude distillation unit designed and constructed by Foster Wheeler for the Humble Oil & Refining Company

Maintenance and Operation—

HOW TO DO IT

HOW—

Crane Cuts Unloading Time

SAND used for sand-blasting in the refinery of Humble Oil & Refining Company at Baytown, Texas is unloaded from railroad cars and dumped into a drier by the somewhat unusual procedure shown in the accompanying pictures.

The revolving-type crane is mounted on a structure on the roof of the four-story filter house. Each trip, the crane's bucket picks up a quarter-yard of sand from the railroad car, raises it onto the roof of the building, and dumps it into the hopper and chute to the drier.

Two men are required to unload the car using the crane. They require eight hours to unload each car. Previously, it required five men eight hours to unload a car by shoveling the sand from the car onto a conveyor which carried it up to the drier inside the filter house.

The new method of unloading saves 24 man-hours per carload of sand.

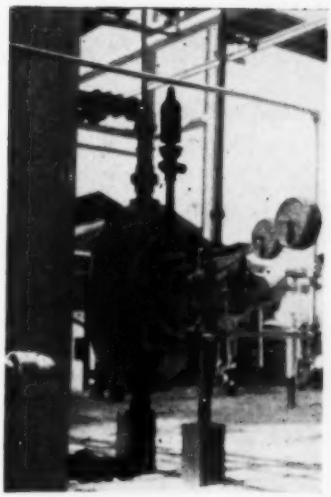
HOW—

Alarm Prevents Condensate Overflow

THE operators at a natural gasoline plant had difficulty with the plant fuel scrubber filling up with raw condensate, when new gas wells were turned into the field gathering system. Raw condensate overflowed surge and flash tanks and entered the vapor system so rapidly and in such quantity that the liquid level control outlet was unable to dump all the fluid to the skimmer basin or storage.

As a result, the excess fluid entered the fuel line to boilers and direct-fired heaters and caused fires.

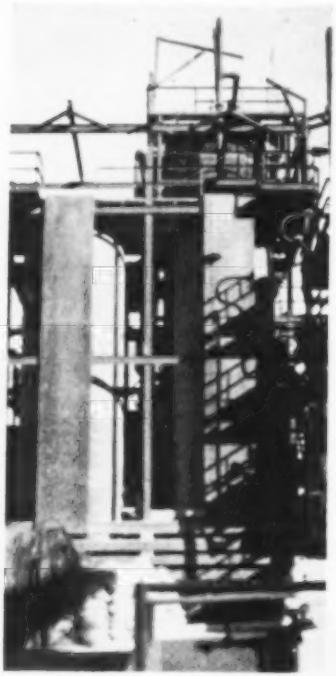
To prevent overflowing, a whistle, operated from the float level arm, was installed on the fuel scrubber. Since installation of this simple device, the operators have been alerted by the whistle to open a two-inch valve on the scrubber to drain the excess fluid, preventing a run-over into the fuel system.



HOW TO—

Speed Loading Of Clay Towers

LOADING of clay treating towers in one refinery was simplified and speeded by installation of permanent slipways up which the bags of clay are hoisted. The slipways, slightly inclined, serve to guide the bags and prevent them from being torn on projections. The hoist is mounted



directly above the slipway. Tank steel, heavy enough to prevent buckling in service, was used in building the slipways. Welded seams were made with clean beads, which offer no projections to damage or tear the clay sacks being hoisted to the top of the tower. The installation of two slipways on clay treating towers is shown in the picture.

HOW—

Powder Cutting Solved Construction Problem

A DIFFICULT problem in refinery construction at a Mid-West refinery was solved by the use of powder-cutting. The inner chamber of a large catalyst tower erected some five stories high, was 3½ inches too long, and had to be shortened in place. The chamber was made of 12-percent chrome steel, one-inch thick. In addition to shortening the column, it was also necessary to cut eight circular holes in the inner chamber to allow heat to pass into the outer chamber while the entire tower was stress relieved in position. The holes were welded closed after treatment.

The job was accomplished in two days time by the use of powder-cutting, which proved to be simplest method of cutting some 70 feet of chrome steel. In the picture, the operator is using a cutting blowpipe with powder-cutting attachments to make the circumferential cut. One of the eight holes cut for the stress-relieving operation is visible over the torch.

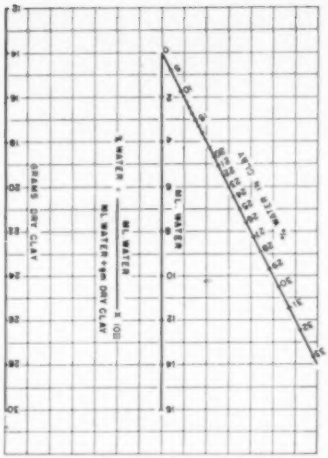
The powder-cutting process provides an easy method to cut material, such as stainless or high-alloy steels, oxidation-resistant to the normal oxy-acetylene flame. An iron-rich powder is blown into the oxygen stream from outside the preheat flame. This powder is heated to ignition temperature by the oxy-acetylene preheat flame. Ignition of the powder creates a high-temperature reaction. As the cutting proceeds, a combined melting and fluxing action continuously removes any refractory oxides formed. Powder-cutting is a process developed by Linde Air Products Company, unit of Union Carbide and Carbon Corporation.

HOW TO—

Calculate Percent Water In Copper Chloride Slurry

SUCCESSFUL treatment of hydrocarbons by the wet copper chloride process often is dependent on maintaining the optimum moisture content of the slurry. In one refinery, control of the moisture is provided by analyzing the slurry once each shift. The test requires about two hours.

A four-ounce sample of hydrocarbon and slurry is withdrawn from the treater and washed into the flask with several benzol washes, totaling about four ounces. After the apparatus is assembled, such as shown in Figure 1 (b), ASTM D95-46, the distillation proceeds until there is no further increase in the water distilled in a ten minute period. Then the still warm water-free slurry is filtered through a previously weighed coarse filter paper on a Buchner funnel using a water-aspirator for suction. The clay is washed out of the flask by successive washings with benzol or natural gasoline. The paper and clay are washed free of kerosine and then dried on a pie pan in an oven at low heat or over an electric heater or steam coil.



Knowing the amount of water distilled and the net weight of dry clay, the water content of the slurry can be determined from the chart. The chart is a useful timesaver in calculating the percentage of water in the copper chloride slurry.

THE MONTH in the INDUSTRY

Stanley Hope Becomes Esso's New President

Hope

Burks

Stanley C. Hope has been elected president of Esso Standard Oil Company, principal domestic manufacturing and marketing affiliate of Standard Oil Company (New Jersey). Former executive vice president and director of the company, he succeeds M. J. Rathbone who joined the parent company as a director. Dr. H. G. Burks, Jr., vice president and director has also been named executive vice president.

Hope is former president of Gilbert & Barker Manufacturing Company and of Stanco Inc. both Standard Oil Company (New Jersey) affiliates, and has been a member of the latter's coordination committee.

Dr. Burks, who joined Jersey Standard as development engineer in 1924, is a director of Standard Oil Development Company. In 1943 he was named director, in 1946 general manager of East Coast Refineries, and in 1948 general manager of manufacturing and was elected a vice president in January.

NGAA Joins National LP-Gas Promotion Plan

Natural Gasoline Association of America's board of directors has approved a five-year national promotional program for the stimulation of LP-Gas markets and sales through national advertising and promotion of LP-gas at the local level. James E. Pew, president of NGAA, said that all producers of LP-gases would be invited to participate. "This campaign can be a great stimulant to our industry," he said. "The great increase in the production of propane and butane in recent years has made this move necessary, not only to assure markets but to avoid waste of these hydrocarbons at their source."

The campaign will be administered by a national promotion committee composed of selected members from the participating associations. The first meeting of the committee was scheduled for November 3-4 in Chicago when plans were to be completed for early launching of the advertising program. A budget of $500,000 has been outlined for 1950 with the anticipation that double this amount is to be required for each of the succeeding four years.

LPGA Names Director

Appointment of Arthur C. Kreutzer as managing director of the Liquefied Petroleum Gas Association has been announced by Si G. Darling, president. Kreutzer will assume the duties of Howard D. White, executive vice president, who resigned to become associated with the newly organized Perlite Development Corporation, Albuquerque, N.M., as an owner and officer. Kreutzer has been counsel and secretary of the association since 1946.

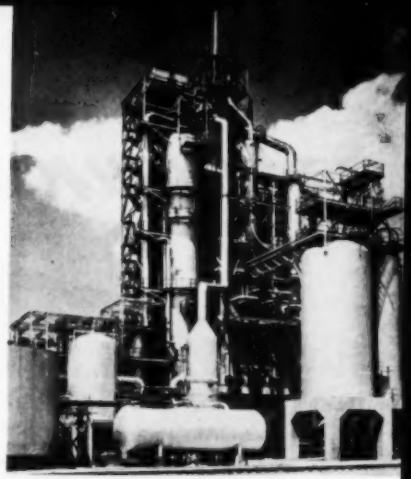
Japan Seeks Crude Oil Bids

Japan is gradually beginning to rebuild its oil refining operations, according to military occupation authorities of Japan who have asked for bids on the delivery of 4 million barrels of crude oil, payable in pounds sterling only. Bids were invited on requirements of 480,000 barrels to be delivered not later than December 15; 480,000 barrels to be delivered not later than January 15, 1950; and 3,045,000 barrels to be delivered by July 15, 1950. Offers were limited to a minimum of 480,000 barrels with the specification that offers could be made on basis of either price landed-in Japan or price port-of-loading.

ASME Elects President, Executives and Directors

The American Society of Mechanical Engineers has elected James Dalton Cunningham president for 1950. He succeeds James M. Todd, consultant engineer of New Orleans. Cunningham is president and founder of Republic Flow Meters Company, Chicago, formerly known as Steam Appliance Company.

Regional vice presidents elected to serve two-year terms on the ASME council are: Frank M. Gunby (re-elected), associate and director of Charles T. Main Inc., Boston; John C. Reed, professor of mechanical engineering and head of the mechanical engineering department, Bucknell University, Lewisburgh, Pa.; Albert C. Pasini, assistant superintendent, production department, Detroit Edison Company, Detroit; Samuel H. Graf, director, engineering experiment station and head of the mechanical engineering department, Oregon State College, Corvallis, Ore.



OHIO OIL'S CAT CRACKER—Climaxing 25 years in petroleum refining, The Ohio Oil Company last month formally opened its modernized and expanded refinery at Robinson, Ill. The multi-million dollar additions include a modern fluid catalytic cracking unit, a 27,000-barrel-per-day crude distillation unit, catalytic polymerization unit, gas-recovery plant, and gasoline treating plant. Auxiliary facilities include a major addition to the power plant, a new water-circulating pump house and cooling tower, an Ethyl blending building, and an API oil separator. An employes service building houses shower rooms and lockers and a cafeteria.

Pictured above is the modern fluid cat cracker designed to process 12,400 barrels of gasoil per day. A new terminal, being constructed at Muncie, Ind., will receive gasoline and other refined products by pipe line direct from the Robinson refinery.

API Executive Committee Proposes Staff Changes

Three leaders of the oil industry—Frank M. Porter, president of Mid-Continent Oil & Gas Association, Baird H. Markham, director of APIC, and R. B. Anderson, (Waggoner Estate)—up until November 1 had successively declined the nominating committee's suggestion that they be nominated for president of the American Petroleum Institute. President William Boyd has announced his intention of retiring.

Pending approval by the full board at the Chicago meeting, the top command of the institute in future years will include a separate chairman of the board as well as a president. The executive committee has approved a change in the by-laws whereby the board chairman is to be selected from the industry and is to serve without compensation. The committee's choices for this position are John M. Lovejoy, Seaboard Oil Company of Delaware, and L. S. Wescoat, The Pure Oil Company. In addition, the committee approved recommendation of a committee of five that the office of president be continued with the same administrative duties as now.

ACCCE Elects Officers

At the annual meeting last month of the Association of Consulting Chemists and Chemical Engineers, Inc., officers and councilors were elected as follows: president (re-elected), Percy E. Landolt, consulting chemical engineer, New York;

★ 100% gas fuel operation — zero pilot fuel!

★ 80% increase in horsepower over ordinary gas engines!

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Supercharged Gas Engines

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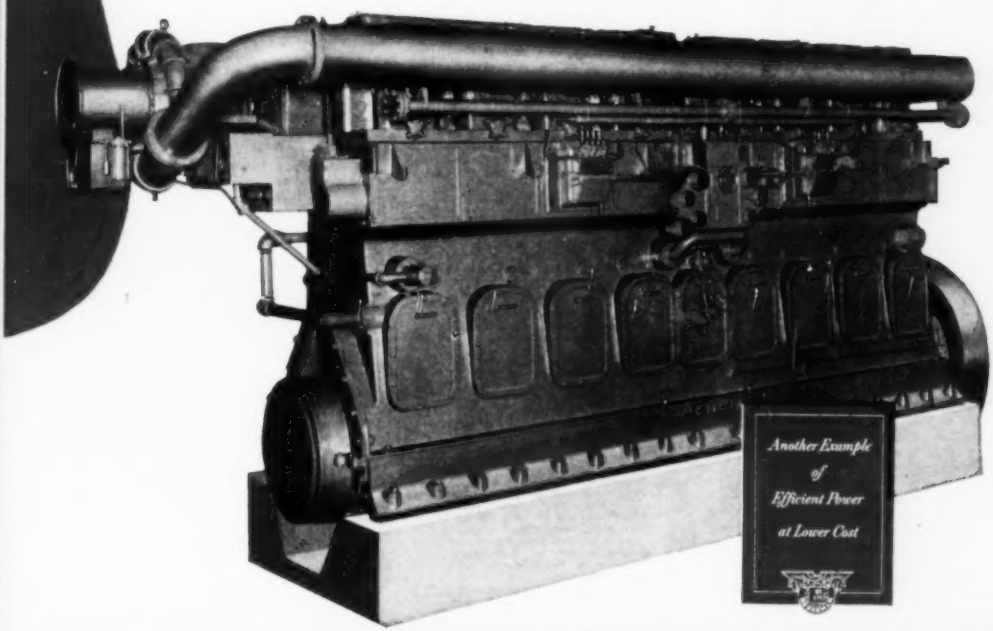
Moreover, by successfully increasing brake-mean-effective pressure from the usual 70 pounds to 125 psi, the new supercharged engines produce 80% more horsepower. Thus any power need can be met with fewer or smaller engines, permitting additional big savings in installation, housing, piping, maintenance and normal operating overhead.

For further data, for specific information on what this new development offers in meeting your particular needs, check with the nearest Cooper-Bessemer office.



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THE MONTH...

vice president, Stephen Laufer, Schwarz Laboratories, Inc., New York; treasurer, Robert S. Aries, consulting chemical engineer, Brooklyn; secretary, Albert Parsons Sachs, consulting chemical engineer, New York; Charles Davidoff, consulting metallurgist, New York; Erwin DiCyan, consulting chemist, New York; Chester L. Knowles, consulting chemical engineer, New York; Harry A. Kuhn, consulting chemist, Washington, D. C.; A. Rooseboom, chemical consultant, New York.

Pew to Receive API Award

J. Howard Pew, director and retired president of Sun Oil Company and one of the founders of the American Petroleum Institute 30 years ago, was to receive the API gold medal for distinguished achievement at the twenty-ninth annual convention being held this month in Chicago. Pew is the fourth to receive the award which was established by the institute in 1946 to pay tribute to prominent Americans who have made outstanding contributions to the public welfare through the petroleum industry.

Pew

During World War I, Pew was a member of the National Petroleum War Service Committee, which subsequently became the first board of directors of the American Petroleum Institute when it was incorporated March 20, 1919, in the District of Columbia. He served 29 years as an API director, retiring from office at the completion of his 1947 term.

California Standard Plant Qualifies for API Award

The Richmond, Calif. refinery of Standard Oil Company of California recently completed more than one million man-hours of work without a disabling injury, to qualify for the American Petroleum Institute million-hour safety award. It is the first time an entire refinery of the company has qualified for the award.

The refinery record was set during the period from August 29 to midnight of October 15, and totalled 1.07 million man-hours, with an average work force of 3655 persons. The average disabling injury rate for oil refineries nationally is slightly more than 8 per million man-hours compared with the company's record of 5.7 per million man-hours at the Richmond refinery for the entire year of 1948.

Grease Institute Board

The National Lubricating Grease Institute last month, re-elected directors for a three-year term as follows: H. L. Hemingway, The Pure Oil Company; J. R. Corbett, Cato Oil and Grease Company; H. P. Hobart, Gulf Oil Corporation; and H. A. Mayor, Southwest Grease and Oil Company. L. W. McLennan, Union Oil Company of California and R. Cubicciotti, L. Sonneborn and Sons, Inc., were elected new members of the board, officers of which are A. J. Daniel, Battenfeld Grease and Oil Corporation, president; Howard Cooper, Sinclair Refining Company, vice president; and E. V. Moncrieff, Swan-Finch Oil Corporation, treasurer. Henry F. Bennetts will continue as executive secretary.

Socony Paint Unit Moves

Executive and eastern sales offices of the paint products division of Socony-Vacuum Oil Company, Inc., have been moved from 111 Broadway, New York, to the administration building of the division's new plant at Metuchen, N. J. This building is one of nine new structures being erected at the plant and is the first to be completed. Early in 1950, it is expected, all the manufacturing operations will be transferred also from the plant in Long Island City. Until then, the Long Island City sales office will remain at its present location. All sales correspondence will be handled by the Metuchen office, however.

THE OIL MAN'S CALENDAR

NOV. 14-18	National Electrical Manufacturers Association, Atlantic City, N. J., Chalfonte-Haddon Hall.
16-18	American Gas Association Technical Section Organization Meetings, New York, Hotel Statler.
27 to Dec. 2	American Society of Mechanical Engineers, Annual Meeting, New York, Hotel Statler.
27 to Dec. 2	Nineteenth Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.
28 to Dec. 3	Twenty-second Exposition of Chemical Industries, New York, Grand Palace.
DEC. 4- 7	American Institute of Chemical Engineers, Annual Meeting, Pittsburg, William Penn Hotel.
9	Natural Gasoline Association of America, Regional Meeting, Amarillo, Texas, Herring Hotel.
1950 JAN. 9-13	Society of Automotive Engineers, Detroit, Hotel Book-Cadillac.
FEB. 27 to Mar. 2	American Society for Testing Materials, Pittsburg, William Penn Hotel.
MAR. 27-29	Western Petroleum Refiners Association, 38th Annual Meeting, San Antonio, Plaza Hotel.
APRIL 3- 5	Society of Automotive Engineers, Aeronautic and Air Transport, New York, Hotel New Yorker.
5- 7	Illinois Institute of Technology, Midwest Power Conference, Chicago, Sherman Hotel.
10-14	American Society of Mechanical Engineers, Washington, D. C., Hotel Statler.
11-13	Southwestern Gas Measurement, Short Course, Norman, Okla., University of Oklahoma.
12-14	National Petroleum Association, Cleveland, Ohio, Hotel Cleveland.
24-25	Industrial Accident Prevention Association, Toronto, Canada, Royal York Hotel.
24-26	Natural Gasoline Association of America, Annual Convention, Fort Worth, Texas, Texas Hotel.
24-26	American Society of Mechanical Engineers, Process Industries, Pittsburgh, William Penn Hotel.
MAY 1- 4	American Petroleum Institute, Division of Refining, Mid-Year Meeting, Cleveland, Ohio, Hotel Cleveland.

Deep Rock Oil Appoints Cushing Refinery Staff

Walterhausen

Howell

A plant manager and seven new department heads have been appointed to Deep Rock Oil Corporation's Cushing, Okla. refinery staff in a major organizational change as follows: K. O. Stowell, plant manager, succeeds George Walterhausen who has retired after 29 years with the company; J. F. McDonald, assistant chief engineer; Quentin Benedict, supervisor of distillation and treating; Raymond E. Feasel, supervisor of cracking; Robert A. Forsman, supervisor of maintenance and shops; Everett W. Hubbard Jr., supervisor of products handling; and Wilson Bentley, industrial engineer.

Walterhausen joined Deep Rock Oil Corporation in 1920 as bookkeeper and stenographer being later promoted to superintendent. Since the retirement of former vice president W. E. Moody, he has served as acting manager. Stowell was former assistant superintendent of Great Southern Corporation's refinery at Corpus Christi and was also superintendent of Humble Oil & Refining Company's butadiene plant at Baytown, Texas.

Hugh A. Stewart Named Interior's Oil & Gas Head

New director of the Interior Department's Oil & Gas Division is Hugh A. Stewart, veteran petroleum geologist who will relieve Carol D. Fentress, director of refining and acting director of the division for the last several months.

Stewart, a long time friend and associate both of Max W. Ball, previous director, and James W. Boyd, director of the U. S. Bureau of Mines, is a 1912 graduate of the Colorado School of Mines. From then until 1919 he was superintendent of Chicksan Mining Company, Korea, beginning his career in the oil industry in 1920 as a geologist for Midwest Refining Company, a Texaco subsidiary. Later he became chief geologist and head of the geological and land departments and from 1936 until his retirement in August, 1948 was Rocky Mountain manager for Texaco.

Oil Eased in Smog Report

Refineries are not the main cause of the smog in Los Angeles, according to a Stanford Research Institute report. Refuting this charge made last year by former director of Smog Control, Dr. Louis C. McCabe, the report states that 40 noxious contaminants contribute to the smog condition, but not one can be singled out as a principal contributor. Gordon Larson, present director says that the cause of the smog is not yet known.

Bloodmobile Visits Oil Offices

Socony-Vacuum Oil Company employes give a pint of blood at a bloodmobile unit installed in the company's New York offices, 26 Broadway, as Red Cross nurses stand in attendance. Employes of Standard-Vacuum Oil Company also participated. More than 130 donations were made through the Red Cross mobile unit and represented the first drive in headquarters offices to establish a Socony-Vacuum "blood credit" with the Red Cross blood program of the Greater New York Chapters. Socony-Vacuum is a pioneer in the volunteer blood program in the New York area, being the first of the major oil companies to participate in the project.

Red Cross hopes to enlist all large petroleum corporations during the coming year, and points to the Socony-Vacuum bloodmobile visit as being one of the most successful undertaken since the inception of the civilian blood program.

Dr. Bernard H. Shoemaker Chosen ACS Chairman-Elect

Dr. Bernard H. Shoemaker, assistant director of research for Standard Oil Company (Indiana), has been chosen chairman-elect of the petroleum division of the American Chemical Society. Other new officers of the petroleum division include: A. A. O'Kelly, Socony-Vacuum Oil Company, Inc., chairman; and C. G. Kirkbride, Houdry Process Corporation, secretary-treasurer. The executive committee comprises A. L. Lyman, California Research Corporation; H. M. Smith, U. S. Bureau of Mines; Louis Schmerling, Universal Oil Products Company; W. A. McMillan, The Texas Company; C. L. Brown, Standard Oil Development Company; and S. W. Ferris, Sun Oil Company.

Pennsylvania Crude Elects Directors, Ad Committee

Three Pennsylvania oil men have been elected directors of the Pennsylvania Grade Crude Oil Association: George H. Daggett of Andrus, Lent and Daggett, Bradford, Pa.; MacLean Houston of United Refining Company, Warren, Pa.; and W. H. Millhiser of The Waverly Oil Works Company, Pittsburgh. The additions brought the board membership to 48. New members of the advertising committee are J. B. Fisher of Kendall Refining Company, Bradford, Pa., and H. A. Logan of United Refining Company, Warren, Pa.

World Crude, Refined Output Shows Decrease

Average world crude oil production during March dropped to 9,206,000 barrels per day from the February average of 8,014,000 barrels per day during February to 7,925,000 barrels per day, according to a Bureau of Mines monthly report. As for the breakdown on major refined products, March increases in production were reported for motor fuel and residual fuel oil, but decreases in amounts of kerosine, distillate fuel oil and lubricating oil refined brought the March average for all major products refined below February's average.

A decrease in average crude production was experienced in North and South America and the Middle East, with increases shown only for Eastern Europe and areas in Africa and the Far East. Average production for Western Europe was unchanged.

ECA, NPC Cite Dangers Of Foreign Oil Increases

Direct disapproval of government programs to expand foreign oil production and refining facilities has been voiced by NPC Chairman Walter S. Hallanan and former ECA petroleum chief Walter J. Levy. Washington's "behind the door discussions" aimed at aiding "those nations desperately fighting for dollars, have brought the most ominous threats we have ever known in keeping the American oil industry on a basis where it can survive the onslaught of foreign competition," Hallanan said. The incredible thing is, he added, that some of our American representatives abroad are willing to finance British oil production to an even greater extent than the British themselves have suggested.

Levy says that these programs for foreign oil expansion with Marshall Plan dollars poses a threat of overexpansion which could stymie development of American petroleum concessions abroad while British projects proceed in the same or neighboring countries at an unprecedented rate.

Instrument Course

Fischer & Porter Company's next instrumentation course will be held at the Hatboro, Pa., plant, January 23-27, 1950. This course will cover manufacture, calibration, installation, operation and maintenance of primary and secondary process control instruments. "Users of the company's line of Flowrator instruments will find the course particularly valuable."

Further details may be had from Fischer & Porter Company, East County Line Road, Hatboro.

Industry's Fire Losses At Three-Year Low Mark

Fire losses reported for the petroleum industry were lowest in 1948 than they have been since 1945, according to a study completed by API's Department of Safety. Figures which now cover a 15-year period show that frequency of oil fires spreading into oil property is seven times that of fire spreading out of oil properties; also, that only one out of every 142 oil property fires spreads outside of the property.

A copy of the study entitled "Fire-Loss Report of 1948 Completes 15-Year Record on Properties, Oil Stocks, and Fires" may be obtained for 5 cents by writing American Petroleum Institute, Department of Safety, 1625 K Street, N. W., Washington, D. C.

Shell Superintendent

George C. Montgomery has been appointed assistant superintendent-administrative of Shell Oil Company's Wilmington-Dominguez, Calif. refinery. He

Montgomery Lorenz

is succeeded by George A. Lorenz as assistant superintendent-operations. Montgomery will be associated in matters relating to personnel, industrial relations, plant protection, safety, public relations, employe activities, and employe training.

Lorenz who joined the company as a research chemist at the Wood River refinery, received his doctor's degree in chemical engineering from the University of Minnesota. For the past 18 months he has been on special assignment in the design of process facilities.

Du Pont Safety Talk

"The three E's of safety—education, engineering, and enforcement—will help reduce accident frequency rates, but further gains will be achieved mainly through developing the proper safety attitude on the part of all employes," B. G. Crane of the Petroleum Chemicals Division of E. I. du Pont de Nemours Company told the Michigan-Ohio group, Fire and Accident Prevention Department of the National Petroleum Asso-

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ciation, at a meeting in Detroit last month. Featured was a discussion of refinery safety and fire problems. Crane stressed the safety attitude on the part of individuals as a problem of salesmanship.

Rensselaer's 125th Year

The Hon. Louis St. Laurent, prime minister of Canada, was main speaker last month at the anniversary celebration of Rensselaer Polytechnic Institute's 125th year as the first college of science and engineering in America.

Continental to Transfer Departments to Houston

Continental Oil Company plans to transfer to Houston early in 1950, a total of 60 employes, including the staffs of six officers of the company and two department heads who have previously been headquartered in Ponca City. Officials who will move to Houston are W. C. MacMillan, executive vice president; Harry J. Kennedy, vice president in charge of marketing; R. L. Bosworth in charge of coordination and planning; A. W. Tarkington, treasurer; and Thos. F. Dowd, controller. Department heads to be transferred are W. E. Webb, manager, production department and John Post, manager, industrial relations department.

Naden

Boyer

Esso Standard Names Three To New Executive Posts

M. W. Boyer, vice president and general manager of manufacturing, has been appointed vice president and contact director for manufacturing, supply and transportation and chemical products operations of Esso Standard Oil Company. William Naden, a director and manager of employe relations, succeeds Boyer as director and general manager of manufacturing. William B. Maloney, assistant to the manager of employe relations, succeeds Naden as manager of employe relations.

Boyer, former vice president of the company in the Louisiana Division and general manager of its Baton Rouge refinery, joined the company in 1927 from the Massachusetts Institute of Technology where he was an assistant and associate in the research laboratory of applied chemistry. He was elected vice president and director of Esso Standard Oil Company in 1945.

Naden joined the company as a chemist at the Everett, Mass., refinery in 1927 and subsequently held positions as general superintendent of that plant and of the Baltimore refinery. After the war, he returned to the company as manager of employe relations and in 1946 was elected a member of the board.

Sinclair Researcher Awarded Ipatieff Prize

Dr. Herman E. Ries Jr. of Sinclair Refining Company research laboratories, Harvey, Ill., has been awarded American Chemical Society's $3,000 Ipatieff prize in chemistry for 1950. Cited for his contributions to the knowledge of catalysts, particularly those used in petroleum hydrocarbon conversion, Dr. Ries will receive the award at the society's 117th national meeting in Houston next spring. He is the second recipient of the prize, the first award being made in 1947 to Dr. Louis Schmerling of Universal Oil Products Company.

The prize, which was established by Dr. Vladimir N. Ipatieff, director of the Ipatieff High Pressure and Catalytic Laboratory at Northwestern University and Mrs. Ipatieff, is given every three years to a scientist under 40 for achievement in the study of catalysis or high pressure.

Du Pont Names Lab Changes

Joseph J. Mikita, director of Du Pont Company's petroleum laboratory at Deepwater Point, N. J., has been promoted to assistant technical manager in the petroleum chemicals division Wilmington, Del. He will be associated

DEATHS

George A. Hill, Jr., 57, president of Houston Oil Company and for years a leading figure in the oil industry, died November 2 in Greenville, S. C., of a cerebral clot. At the time of his death, he was also president of Houston Pipe Line Company, and was recently mentioned as a nominee for presidency of the American Petroleum Institute, which he had already served for 12 years as vice president for production. Service awards had been given him by the API and the Mid-Continent Oil and Gas Association for his service to the Texas and national oil industry. A former director of the Mid-Continent Oil and Gas Association, he was also vice chairman of the oil policy committee of the Independent Petroleum Association of America, a member of the National Petroleum Council, vice president of the Oil World Exposition, and a member of the American Institute of Mining and Metallurgical Engineers. From 1944 to 1945, he was petroleum advisor of the Anglo-American Oil Treaty for the Secretary of the Interior, and for ten years had been a member of the Business Advisory Council for the Secretary of Commerce. During World War II, he was with the executive, production and historical committees and chairman of the facility security committee of the Petroleum Industry War Council.

Hill

Douglas B. Hobbs, 49, in charge of motion pictures educational and technical information activities of the public relations and advertising department of Aluminum Company of America died October 11 in New York. Hobbs joined Alcoa in 1923, and was transferred to the public relations department in 1929.

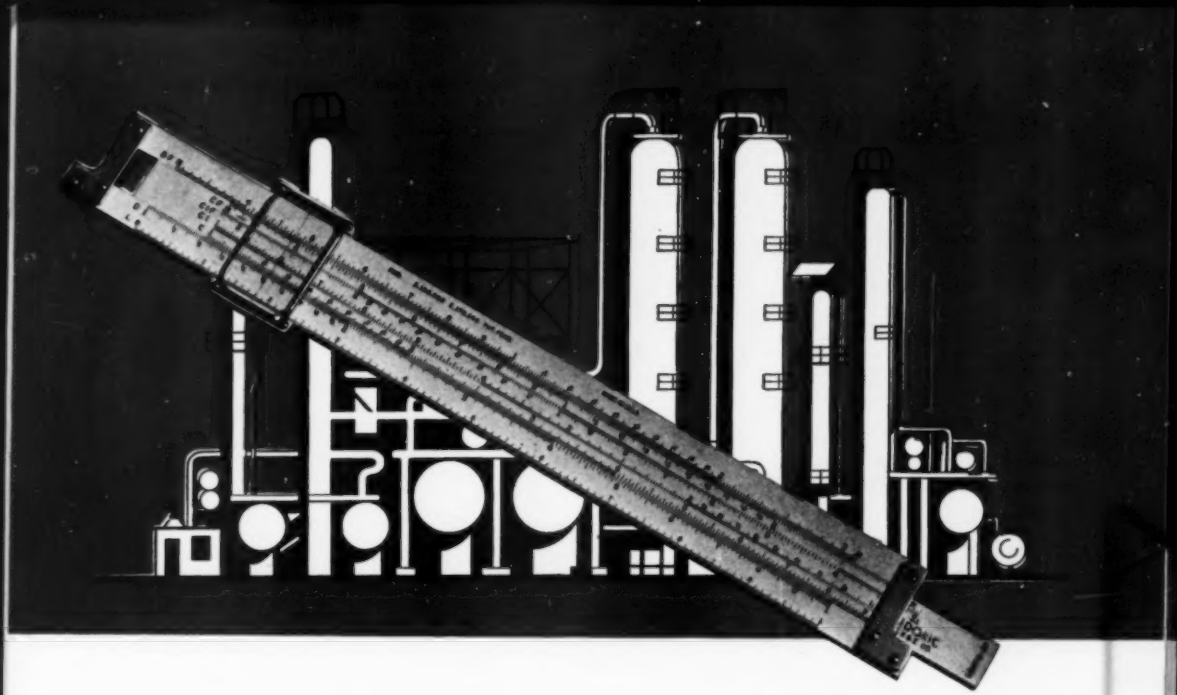
Samuel Hay Wallace, 60, managing Director of Caltex (Africa) Limited, died in Cape Town, South Africa, October 9. He started in the oil business with The Texas Company in 1913, where his father was one of the first managers in the early days of the Export Department.

Walter Dumont, 64, manager of The Pure Oil Company's Washington, D. C. office since April 1943, died October 20. He had been with the company since 1934, having served in various capacities at Reading, Pa., Beaumont and Chicago. For almost two years during the war he served as director of transportation for District 2 of PAW.

William Larimer Mellon, 81, a founder of Gulf Oil Corporation and its active head for 45 years, died October 8 in Pittsburgh. On May 26, 1948, Mellon retired as chairman of the board of Gulf, but he continued to serve as a director. Mellon began in the oil business in western Pennsylvania, where in 1889 he started drilling wells and shipping crude to market in tank cars. He later sold these interests, but again entered the petroleum field in 1901, with the Spindletop discovery in Texas. Gulf Oil Corporation was then organized to consolidate various oil interests, and Mellon was elected a director and vice president. In 1909 he was elected president, and in 1931 he became chairman of the board of directors and chairman of the executive committee.

Mellon

Brian R. Muirhead, vice president and treasurer of Universal Oil Products Company, Chicago, died suddenly October 20 while enroute to Detroit, on a business trip. Well known throughout the oil industry, Muirhead was previously treasurer of Arkansas Natural Gas Corporation, Shreveport, La., and was particularly active in connection with the construction of petroleum defense plant facilities during World War II. A native of Dresden, Kan., he was graduated from Washburn College, Topeka, with a B.S. degree, and did graduate work at the University of Nebraska.



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there with John R. Sabina, the division's technical manager. Mikita was succeeded at the laboratory by the head of its engineering division, Milton H. Campbell. Iver T. Rosenlund, manager of the company's road testing laboratory at El Monte, Calif., was transferred to Wilmington to engage in technical service work.

Mikita who joined Du Pont Company in 1946, has been director of the company's petroleum engineering laboratory. Previously he served as assistant supervisor of engineering research and as associate director of research with The Texas Company.

Lack of Tankage Closes Sunray's Allen Refinery

Sunray Oil Corporation's 7000-barrel-per-day Allen, Okla., refinery has been shut down for an indefinite period for necessary cleanout and repairs due to the inability of steel contractors to deliver tankage for six 55,000-barrel gasoline storage tanks at Drumright, Okla. Company officials said resumption of operations largely will depend on delivery of tankage for product storage and development of more flexible operation in pipe line delivery.

The Allen refinery, which does not have a cat cracker, has for the past two years been operated as an auxiliary to the company's 20,000-barrel-per-day catalytic cracking unit at Duncan, Okla., which will continue to operate.

Natural Gas Group Plans Panhandle Regional Meet

The third annual regional meeting of the Natural Gasoline Association of America for the Panhandle Plains area will be held in the Herring Hotel, Amarillo, Texas, December 9. The program will be largely concerned with discussions of operating problems and will feature a symposium on plant cooling.

Papers scheduled for the **morning session** include: "Selection, Operation and Maintenance of Air Cooling Equipment," M. A. Ellsworth, The Fluor Corporation, Tulsa; "Selection, Operation and Maintenance of Water Cooling Towers," Neal B. LauBach, Hudson Engineering Corporation, Houston; "Use of Natural Gas as a Coolant," F. S. Young, Panhandle Eastern Pipe Line Company, Liberal, Kan.; "Control Instrumentation Applied to Light Ends Fractionation," V. V. Tivy, The Foxboro Company, Foxboro, Mass.

Subjects scheduled for the afternoon session are "The America of Tomorrow—What Will It Be?", James E. Allison, Warren Petroleum Corporation, Tulsa; "Automatic Compressor Stations," T. S. Bacon, Lone Star Producing Company, Dallas; "Automatic Package Units for Gas Dehydration," Alec Francis, National Tank Company, Tulsa; "Operating Problems Relating to Gas Sweetening," J. A. Conners and A. J. Miller, Phillips Petroleum Company, Bartlesville, Okla.

Alcoa Hydraulic Engineer

B. J. Fletcher has been named assistant chief hydraulic engineer for Aluminum Company of America. Fletcher joined Alcoa in 1926 as a member of the hydraulic engineering department. In 1931 he was transferred to the company's development division and was made chief engineer of that organization in 1944.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
Trends in Week Ended	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1948:									
January 31	5,316	5,434	228,083	18,986	102,973	7,600	37,733	9,141	35,510
February 28	5,387	5,463	226,860	18,796	111,040	7,963	30,089	8,824	34,742
March 27	5,377	5,324	229,409	15,782	112,991	7,682	27,483	6,854	33,483
April 24	5,418	5,517	226,486	16,515	111,129	6,831	30,806	8,877	34,437
May 29	5,452	5,715	228,979	17,827	107,185	7,054	34,862	9,508	38,660
June 26	5,494	5,674	229,632	17,938	104,178	7,200	41,137	8,836	42,558
July 31	5,435	5,718	230,720	17,646	99,116	6,823	52,429	9,080	48,618
August 28	5,529	5,682	229,873	17,722	93,504	7,491	61,814	8,818	53,544
September 25	5,343	5,283	234,193	18,705	90,410	6,686	71,428	8,380	57,745
October 30	5,604	5,626	238,752	17,869	91,925	7,679	77,118	8,853	60,845
November 27	5,617	5,721	244,240	17,317	89,802	7,476	80,375	8,477	63,960
December 25	5,641	5,784	250,555	18,178	100,286	7,776	74,876	9,121	63,374
1949:									
January 29	5,493	5,400	255,459	17,531	114,677	7,547	63,142	8,178	63,333
February 26	5,401	5,412	261,965	17,621	124,382	7,450	54,008	8,225	59,348
March 26	5,188	5,353	266,506	17,417	128,087	6,167	48,721	8,306	58,792
April 30	4,986	5,273	271,235	17,980	124,787	6,691	49,980	8,195	60,174
May 28	4,951	5,297	275,190	18,324	120,661	5,943	55,971	8,144	63,758
June 25	4,944	5,322	274,114	18,462	115,715	5,148	63,040	7,886	66,146
July 30	4,731	5,187	271,999	18,038	109,964	6,293	70,767	7,205	67,166
August 27	4,709	5,215	264,458	18,180	105,280	6,491	74,716	7,397	66,394
September 24	4,933	5,377	259,189	18,152	103,262	6,855	81,414	7,419	68,143
October 29	5,075	5,509	252,089	19,002	103,915	7,016	90,358	7,784	69,459

ASME 1949 Conference Hears Hydrogenation Topics

Twelve presentations on subjects of current interest ranging from gas turbines in the refinery to equipment and material in the Bureau of Mines' coal hydrogenation plant at Louisiana, Mo., were heard in Oklahoma City, October 2-5 when the petroleum division of the American Society of Mechanical Engineers held its annual conference. Approximately 200 persons attended the sessions on refining, which were under the direction of P. E. Frank, Sinclair Refining Company, chairman.

Discussions concerning the coal hydrogenation plant included: J. T. Donovan, mechanical engineer; J. A. Markovits, assistant chief, Bureau of Mines, and M. Josehans, special engineer, Koppers Company, Inc., Louisiana, Mo., "High-Pressure Vessels in Coal Hydrogenation Service"; and Markovits and J. H. Sandaker, mechanical engineer, Bureau of Mines, and K. B. Bredtschneider, special engineer, Koppers Company, Inc., "High-Pressure (10,300 psi.) Piping, Flanged Joints, Fittings and Valves for Coal Hydrogenation Service."

"Instrumentation for Coal Hydrogenation Service" was given by G. L. Bruno, project engineer, and F. W. Geyer, senior engineer, Bechtel Corporation, and Markovits. A discussion on "Metallurgical and Fabrication Considerations in the Coal Hydrogenation Demonstration Plant Construction" was presented by R. H. Leonard, Jr., mechanical engineer, G. D. Gardner, metallurgist, and Markovits of the Bureau of Mines. "The Design of Preheaters and Heat Exchangers for Coal Hydrogenation Plants" was presented by P. W. Laughrey, chemical engineer, W. I. Gwillim, chemical engineer, and Markovits of the Bureau of Mines, and H. Schappert, special engineer of Koppers Company, Inc.

Other presentations included "Application of Gas Turbines in the Refinery," C. F. Codrington, chief engineer, blower and condenser department, Allis-Chalmers Manufacturing Company, Milwaukee; "Characteristics of Diaphragm Motor Valves," Thomas L. Smith, chief field engineer, Belfield Division, Minneapolis-Honeywell Regulator Company, Houston; "American Standard Steel Pipe Flanges—Their Development and Proper Usage," J. D. Mattimore, chief engineer, Tube-Turns, Inc., Louisville, Ky.; "Reports on the Behavior of Some Welds at Sub-Zero Temperatures," T. N. Armstrong, metallurgist, International Nickel Company, New York; "Control Valve—Its Application," J. A. Pellettere, chief instrument engineer, Gulf Oil Company, Pittsburgh; "Problems Associated With the Lining of Refinery Vessels With Corrosion Resisting Materials," G. C. Carpenter, corrosion engineer, Esso Standard Oil Company, Baton Rouge, La., and "Application of Ni-Resist and Other Nickel Containing Cast Iron to Pumps, Compressors, and Other Pieces of Petroleum Equipment," Fred Sefing, metallurgist, International Nickel Company, New York.

Sonneborn Moves Offices

L. Sonneborn Sons, Inc. has removed its executive and general offices; white oil and petroleum division; Amalie motor oil division; textile chemicals division and export division to 300 Fourth Avenue, New York 10. The Building products division, however, will remain at 80 Eighth Avenue, New York 11.

OIIC Booklet Portrays World War Oil Years

Statistics of the oil industry through the aftermaths of World Wars I and II and the periods of prosperity and depression are contained in "Petroleum Industry Record—1918-1948," a booklet prepared by the American Petroleum Institute for the Oil Industry Information Committee. Tables and graphs portray the development of the industry through the past three decades and the expanding use of petroleum as a source of energy for light, heat, power, transportation and mechanization. The tables and charts, on a year-by-year basis, cover subjects of crude oil production and producing wells, drilling activity, proved reserves and allied cumulative figures, refining capacity and runs to stills, average yields per barrel, specialized yields, domestic demand and exports of motor fuels, kerosine and fuel oils, wholesale price indices and world crude oil production.

Single copies of the booklet may be obtained for 50 cents by writing J. A. McNally, American Petroleum Institute, 50 West 50th Street, New York 20. Bulk orders are available at the following rates: 1 to 50 copies, 50 cents each; 51 to 100 copies, 35 cents each; 101 copies and up, 25 cents each.

Texas Company Lists Several Appointments

The Texas Company has appointed the following: W. J. B. Dixon, assistant to the vice president (foreign); H. D. Teeters, assistant to the vice president (domestic); Elihu Madison, manager of the company's economics department; and Dr. Curtis H. Bylor, assistant medical director of the company.

Dixon was formerly an assistant treasurer, handling foreign financial matters, and Teeters was also formerly an assistant treasurer handling domestic financial

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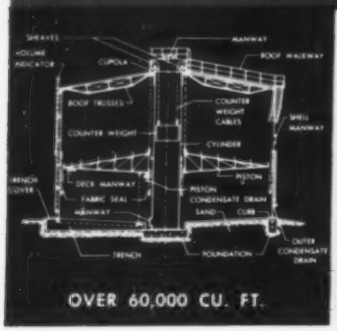
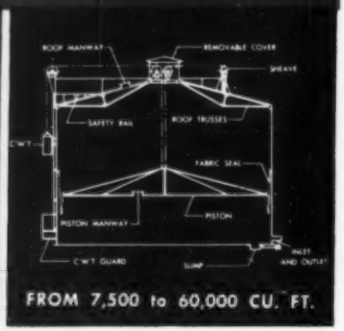


OVER 60,000 CU. FT.



FROM 7,500 to 60,000 CU. FT.

have proved a profitable investment, because they offer . . .

1. A Gasholder with efficient operation and easy maintenance.

a. Not affected by snow load since all moving parts are under cover.
b. All major moving parts accessible for inspection during operation.
c. A vapor balancer that can be made gas free for repairs in a few hours.
d. A vapor seal that has a life equal to that of the tank.
e. A Gasholder working pressure of ⅛ to ¼ inch of water.

2. A vapor balancer that has a 100% Dry Seal.

a. Eliminates corrosion problems attendant with wet seals.
b. Requires no heating system during freezing weather.
c. Has no evaporation loss through a water or oil seal.
d. Requires no attention, adjustment or lubrication.

3. One vapor balancing mechanism for all tanks.

a. Provides flexibility of operation.
b. Permits repair of any tank in group without affecting operation.
c. Allows vapor balancer to be removed without disturbing storage tank operation.
d. Accomplishes all venting through one master valve.
e. One structure for protection of all standing and pumping loss.

For more complete details and Pay-Out Analysis, write for Bulletin VB-10

GENERAL AMERICAN TRANSPORTATION CORPORATION

WIGGINS VAPOR SEALS GENERAL AMERICAN

135 SOUTH LA SALLE STREET, CHICAGO 90, ILLINOIS

BRANCH OFFICES: New York • Washington, D. C. • Cleveland
Buffalo • Pittsburgh • New Orleans • Tulsa • Refin
Boston • Seattle • Los Angeles • St. Louis • San Francisco

Sub-licensees

WESTERN STATES: Consolidated Western Steel Corporation — San Francisco — Los Angeles
SOUTHERN STATES: Wyatt Metal and Boiler Works, Houston — Dallas, Texas
GREAT BRITAIN: Motherwell Bridge & Engineering Co., Ltd., Scotland
FRANCE: Etablissements Delattre & Frouard reunis, Paris
CANADA: Toronto Iron Works Ltd., Toronto

THE MONTH . . .

matters. Dr. Baylor was graduated from John Hopkins Medical School and was former professor of medicine at the American University of Beirut, Lebanon.

Says Refinery Dispersal Is No Atomic Defense

"Little possibility exists for the development of many new and diverse refinery locations" as a defense against atomic bombings, Commander Robert C. Wing, U. S. Navy, said last month. "The economic laws are such that expansion through integration with existing facilities gives operating economies, lower cost in steel, manpower, utilities, and housing savings that cannot be achieved through the erection of completely new units. The short supply and high cost situation in steel, housing, skilled manpower, and the struggle for operating profits make the trend for concentration virtually inevitable." Other branches of the industry, Wing said, including production, are less subject to substantial disruption because they are not so concentrated as refining.

Commerce Department Plans Industry Survey

The Commerce Department's Office of Business Economics is planning a survey of oil industry capital expenditures in fields of refining, production, transportation and marketing. Figures will be correlated with those of other industries to point up relationship between capital investments and business prosperity in general.

American Cyanamid Names Manager and Europe Agent

Dr. L. P. Moore has been appointed manager of American Cyanamid Company's new products development department and Dr. E. W. Cook as the company's European technical representative.

Dr. Moore has served as the company's European technical representative since 1946. He has been with the American Cyanamid Company for 12 years. In his new work, he will supervise new products development and market research activities.

Dr. Cook, who received his degrees from the University of Arkansas and Ohio State University, joined American Cyanamid Company in 1940. He came to New York in 1946 as assistant chemical director of the company.

Lukens Board Chairman

Robert W. Wolcott, president of Lukens Steel Company since 1925, is new chairman of the board, and Charles Lukens Huston Jr., vice president and executive assistant to the president since 1948, is now president of the company.

American Gas Officers

American Gas Association officers elected for 1949-1950 are Hugh H. Cuthrell, vice president The Brooklyn Union Gas Company, Brooklyn, presi-

THE MONTH . . .

dent; D. A. Hulcy, president Lone Star Gas Company, Dallas, first vice president; George F. Mitchell, president The Peoples Gas Light & Coke Company, Chicago, second vice president; and Edward F. Barrett, president Long Island Lighting Company, Mineola, N. Y., treasurer.

ECA Predicts Increase In 1953 Crude Output

Projected increases in refinery throughput in the countries participating in the European Recovery Program account for a large part of the annual production of crude oil in the world outside of North America and Eastern Europe which the Economic Cooperation Administration has predicted will be 100 metric tons greater in 1953 than in 1948. This potential increase is shown in a statistical summary of plans for the expansion of world oil production and refining, compiled in Washington last summer from individual oil company programs and from other sources by representatives of the United Kingdom and the Netherlands governments and of ECA.

Crude runs to stills will rise from 19.2 million tons in 1948 to an estimated 64 million in 1953, if all refinery expansion plans are fulfilled. If, in addition to the output of those refineries, imports of refined products into the OEEC countries reach the level now estimated by the major companies, these countries would have a total of 72.1 million tons of refined products available for consumption in 1953, compared to 45.1 million tons in 1948.

Dulien Steel Purchases Cotton Valley Refinery

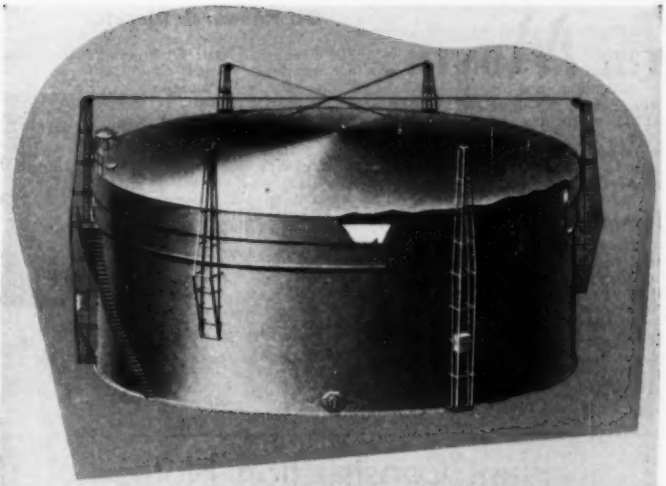
Dulien Steel Products, Inc. of Seattle, Wash. has purchased the Cotton Valley, La. refinery from the government for liquidation. It is being offered for resale as a whole unit or piece by piece. Designated as Plancor 592, it was appraised in 1947 at the present day reproduction cost of nearly $7.5 million and at the re-use value of nearly $2 million. The major processing facilities comprise a dehydrogenation unit, an HF alkylation unit, and a tetraethyl lead blending plant.

Monsanto Selects Thomas

Monsanto Chemical Company has elected Dr. Charles Allen Thomas chairman of the company's five-man executive committee. President William M. Rand remains a member of the executive committee, other members being Edgar M. Queeny, chairman of the board of directors; Osborne Bezanson, vice president, R. R. Cole, vice president, and F. J. Curtis, secretary.

Ethyl Price Reduced

Ethyl Corporation has reduced the price of "Ethyl" antiknock compound one cent a pound for both motor and aviation mix. This change was effective for all shipments made on and after October 25. The new prices are 56.7



THE WIGGINS DRY SEAL LIFTER ROOF

. . . can be used to conserve the vapors of a single tank, on which it is installed, or it can serve as a vapor balancing unit of several interconnected tanks.

ADVANTAGES

THE SEAL	1 — 100% dry seal eliminates corrosion, heating and freezing problems. 2 — No maintenance other than periodic inspection required. 3 — No possibility of stored product being absorbed in seal and creating a fire hazard. 4 — Out-of-level tank grade does not affect seal operation.
COUNTER BALANCE SYSTEM	1 — Reduces operating pressure to 1¾" water. 2 — Reinforcement of interconnected tanks not required. 3 — All mechanism completely accessible from outside. 4 — Not affected by out-of-level tank grade. 5 — No lubrication required.
PRESSURE VACUUM RELIEF	1 — No leakage, absolutely gastight. 2 — All working parts outside tank and readily accessible for inspection. 3 — Simplicity. Single valve serves for both pressure and vacuum relief.

For further details, write for a copy of Bulletin VB-10.

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 SOUTH LA SALLE STREET, CHICAGO 90, ILLINOIS

BRANCH OFFICES: New York • Washington, D. C. • Cleveland • Buffalo • Pittsburgh • New Orleans • Tulsa • Dallas • Houston • Seattle • Los Angeles • St. Louis • San Francisco

WIGGINS VAPOR SEALS GENERAL AMERICAN TRADE MARK

Sub-licensees

WESTERN STATES: Consolidated Western Steel Corporation San Francisco — Los Angeles

SOUTHERN STATES: Wyatt Metal and Boiler Works, Houston — Dallas, Texas

GREAT BRITAIN: Motherwell Bridge & Engineering Co., Ltd., Scotland

FRANCE: Etablissements Delattre & Frouard réunis, Paris

CANADA: Toronto Iron Works Ltd., Toronto

THE MONTH . . .

cents per pound of tetraethyl lead content for motor mix (approximately 0.2063 cents per cubic centimeter), and 62.2 cents per pound of tetraethyl lead content for aviation mix (approximately 0.2263 cents per cubic centimeter).

Sinclair Ad Manager

James J. Delaney has been appointed advertising manager of Sinclair Refining Company. Formerly a vice president of Morey, Humm & Johnstone, Inc., and an account executive with McCann-Erickson, Inc., Delaney's 20 years of advertising and promotion experience also includes eight years as assistant advertising manager of Cities Service Company.

OU Research Director

Verne H. Schnee, formerly assistant director of Battelle Memorial Institute, has been named director of the University of Oklahoma Research Institute in Norman, Okla. A graduate in chemistry from Cornell University, he is the first full-time chairman of the OU institute. During World War II, he was chairman of the products research division of the war metallurgy committee of the National Research Council. Later Schnee was appointed chairman of the committee on ship construction of the division of engineering.

Schnee

ularly lacquers and enamels, in hydraulic brake fluids and antifreezes. This new laboratory is termed "the latest step in a continuing expansion program by Shell Chemical's Corporation in the manufacturing and marketing fields." Dr. Herr and his staff will conduct investigations in customer problems wherever the use of Shell Chemical product is involved. The findings of all investigations, except those undertaken on a confidential basis for a particular customer, will be made available to the industry.

Shell Completes Major Modernization at Ventura

Shell Oil Company has completed a major modernization program at its Ventura, Calif. natural gasoline absorption plant. Originally built in 1926 it is considered one of the most modern plants in California and has for the past 20 years produced an average of approximately 100,000 gallons of liquid hydrocarbons per day.

One of the units recently installed is a large fractionating column, or "fat oil de-ethanizer." This 100-foot column is the first such unit installed in a natural gasoline plant on the Pacific coast, and makes possible the recovery of a high percentage of the potential propane without costly operations at sub-zero temperatures and expensive dehydration facilities.

Plant Construction Notes

(Also see Construction "Boxscore," Page 87)

Esso Completes New Cat Cracker Plant at Bayway

Esso Standard Oil Company, affiliate of Standard Oil Company (New Jersey) has completed its Bayway, N. J. refinery's fluid catalytic cracking unit, the largest in the world. Completion of this project marks the finish of a two-year refinery expansion and modernization program.

The new catalytic cracker which has a daily capacity of 41,000 barrels, will produce almost a million gallons of gasoline, 250,000 gallons of heating oil and 270,000 gallons of other distillates a day.

Also on stream and working in conjunction with the cat cracker, is a new 49,000 barrel per day vacuum pipestill which receives residual oil and prepares from it a feed stock for the new catalytic cracking unit.

According to the company, the result of these improvements and others at Bayway will be to permit a minimum production of residual oil products—like No. 6 heavy fuel oil—a maximum production of more valuable products, like gasoline and heating oil.

Chalk Hill Plant Opened

The Texas Company and associates' Chalk Hill gasoline plant, located in Archer County, Texas, has begun operations. The plant, which is owned by The Texas Natural Gasoline Corporation and W. A. Moncrief, is processing approximately 1500 mcf. of casinghead gas daily and is producing natural gasoline, propane and liquefied petroleum gas mixtures. Constructed by The Texas Company, operator, and O. L. Olsen, contractor, the plant is supervised by C. B. Williams, Fort Worth division manager, West Texas Division, Texaco Producing Department.

Copper Treater Completed

Continental Oil Company has completed a 20,000-barrel-per-day Perco liquid copper treater at its Ponca City, Okla., refinery. This unit, which consists of four independent 5000-barrel-per-day sections, will treat straight-run and cracked gasolines as well as kerosine and burning oil fractions. The treater has been on stream since August.

First Lube Cargo Shipped From New Citcon Plant

A cargo of bulk lubricating oil, high viscosity index solvent refined bright stock and neutral, was shipped last month from Citcon Oil Corporation's Lake Charles, La. 6000-barrel-per-day plant destined for Petty's Island, N. J., a terminal of Cities Service Oil Company. This is the first in a regular schedule of cargo shipments from the plant, jointly owned by Cities Service and Continental Oil Company.

Sohio Completes Modern Cat Cracker at Lima

Joining with city and county officials in ceremonies October 19, The Standard Oil Company (Ohio) marked the opening operation of its new $11 million fluid catalytic cracking plant at the Lima, Ohio, refinery. The unit is expected to run 16,000 barrels per day.

In addition Sohio is also constructing a continuous crude and coking unit costing $5.5 million and a new solvent refining plant costing $13.6 million, as well as new tankage totaling 200,000 barrels and costing $240,000, and a new liquid gas plant costing $225,000, plus an office building and laboratory.

Shell Chemical Opens Technical Service Lab

Shell Chemical Corporation has opened a new technical service laboratory at Union, N. J., designed to benefit industries using petroleum-derived chemicals. Under the direction of Dr. Donald S. Herr, who previously directed the company's technical service laboratory at Martinez, Calif., the new laboratory will study, in particular, the application of chemicals in surface coatings, particularly lacquers and enamels, in hydraulic brake fluids and antifreezes. This new laboratory is termed "the latest step in a continuing expansion program by Shell Chemical's Corporation in the manufacturing and marketing fields." Dr. Herr and his staff will conduct investigations in customer problems wherever the use of Shell Chemical product is involved. The findings of all investigations, except those undertaken on a confidential basis for a particular customer, will be made available to the industry.

Frontier Constructing Cheyenne Coke Unit

Work started on a two-coil Dubbs integral coking unit at Frontier Refining Company's Cheyenne, Wyo., refinery scheduled for completion late next spring. The new unit will have a charge capacity of 2400 barrels per day and produce 105 tons of coke daily. This will enable the company to increase the octane number of its thermally cracked gasoline and make residual production more flexible. Process engineering design is by Universal Oil Products Company, with mechanical engineering and construction by Refinery Engineering Company.

Present crude capacity of the refinery is 10,500 barrels per day, with 2500 barrels per day catalytic cracking and 2250 barrels per day thermal cracking capacity. This new addition will increase the thermal cracking capacity to 3500 barrels per day.

CCA Plans Modernization Of Co-Op Owned Refinery

During the coming year Consumers Cooperative Association expects to modernize the "world's largest first complete co-op owned refinery" at Phillipsburg, Kans. Last month at district meetings in Aberdeen and Sioux Falls, S. Dak., Howard A. Cowden, president and general manager of the association, said that margins in the petroleum industry last year shifted from refining to retailing.

Pan Am Awards Contract For Texas Desulfo Unit

Pan American Refining Corporation has awarded a contract to Tellepsen Construction Company, Houston, for the erection of a $250,000 desulfurization unit at its Texas City refinery. The new

● Experimental laboratory condenser, with water boxes removed, designed by The American Brass Company and tubed with eight different copper alloys, as it appeared after 10-month test, July 28, 1947 to May 25, 1948, at the Marine Test Station of International Nickel Co., at Kure Beach, N. C. *(see above).*

ANACONDA Cupro-Nickel 754

(10 PERCENT NICKEL CONDENSER TUBE)

MANUFACTURED AND SOLD UNDER U. S. PATENT NO. 2,074,604

Shows High Resistance Under Accelerated Test

TEN months of testing with high velocity sea water at Kure Beach, N. C., demonstrate the superiority of Anaconda Cupro-Nickel 754 (nominal composition, copper 89.25 percent, nickel 10 percent, iron .75 percent) over a number of widely used condenser tube alloys.

The purpose of the test was to determine the resistance of various standard tube alloys to corrosion-erosion type of deterioration caused by turbulent flow of sea water. The tubes are .625″ O. D., 18 gage (.049″), and 61 inches long. The average velocity of sea water flowing through the tubes, during the continuous 10-month test, was 11.7 feet per second. Water temperature varied from 45°F. to 85°F., according to the season of the year.

This test, and performance records where Cupro-Nickel 754 tubes have been in service under severe operating conditions, indicate that this tube and tube sheet alloy will give economical service for central station and marine condensers handling clean and some types of polluted sea waters. The American Brass Company welcomes opportunities to discuss problems relating to condenser tubes, and the services of its Technical Department are available for assistance in selecting alloys to meet specific operating conditions. 49138

ANACONDA

Anaconda

CONDENSER TUBES

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

THE MONTH . . .

unit is designed to remove the sulfur content from crude oils received at the plant from various Southwest oil fields. Construction is to begin immediately with completion scheduled for early 1950.

Esso Plans Gas Plant, New Virginia Terminal

Esso Standard Oil Company is constructing a $40,000 propane bottling plant on a newly acquired 128-acre tract below Richmond, Va. on the James River. On this site an oil terminal is also planned which would replace its 60-year old barge terminal in Richmond. Plans also call for a new $750,000 "boat" terminal to be started perhaps in 1951.

These are tentative plans, however, which may be scaled up or down. A larger terminal may be built if a 35-foot river channel to Richmond is provided.

Texaco Gets New Buildings For Eagle Point Refinery

Three additional new buildings for The Texas Company at its Eagle Point plant near Camden, N. J., have been completed by Wigton-Abbott Corporation, engineers and contractors of Plainfield, N. J., The new structures include a one-story fireproof sample storage building of steel frame construction with explosion-proof electrical work and blow-out roof panels; a one-story carpenter shop; and a one-story laboratory measuring 55 by 100 feet. A modern one-story cafeteria building is also being completed at the same plant.

French Maintenance Job

T. Ellwood Webster, president of Catalytic Construction Company, Philadelphia, has announced the signing of a contract for major maintenance with Shell-Berre in France. The refinery's principal equipment is a three-case, 5000-barrel-per-day Houdry cat cracking unit. The work will be supervised by Oliver E. Benoit who has been field superintendent on similar operations in the U. S.

Propane Bottling Plant

Construction by Socony-Vacuum Oil Company, Inc. of a new plant for handling and filling cylinders of bottled gas, under way in Burlington, Vt., will be completed within a few months. A feature of the new building, which has a capacity of 100 cylinders per day, is a device for steam-de-icing of cylinders in wintertime.

Shamrock Constructing Unit

Shamrock Oil and Gas Corporation is constructing at its Sunray, Texas, refinery a Perco cycloversion unit designed for a capacity of 1500 barrels per day. Upon completion, scheduled for early 1950, the unit will be operated for both gas oil cracking and naphtha reforming. The catalyst chamber sections have been designed for completely automatic valve control.

Named Standard Executive

William H. Beekhuis has been elected a vice president of Standard Oil Company of California. Beekhuis, an economic counselor and formerly assistant comptroller of the company, has acted as secretary of the executive committee for the past six months. He has been associated principally with the company's manufacturing activities since his graduation in 1930 from the University of California.

Beekhuis

Houston Steel Pipe Mill By Consolidated Western

Houston has been chosen as the site for a new electric welded steel pipe mill to be built by Consolidated Western Steel Corporation. Preliminary construction work has begun on property owned by the company near the Houston Ship Channel. The new plant is scheduled for completion in the spring of 1950.

New facilities will provide an annual capacity of 100,000 net tons of 24-inch diameter and larger electric welded and expanded steel pipe, and will enable Consolidated Western Steel Corporation to compete in the Texas area, and particularly in the market for large diameter pipe required for long distance oil and gas pipe lines. The new plant's capacity will be approximately 50 miles of large diameter pipe a month. At present United States Steel has no facilities for the production of this type of pipe east of the Rocky Mountains or south of the Pittsburgh area.

NCIA an ISA Affiliate

The Northern California Instrument Association will become the Northern California Section of the Instrument Society of America when it receives a charter November 21 at Emeryville, Calif. To be held is a panel discussion on "Fractionation Column Control." Dr. A. O. Beckman, national vice president of the ISA will present the charter to C. S. Beard of Bechtel Corporation, president of NCIA.

Engineering Award

Rules and conditions for the 1949-1950 engineering undergraduate award and scholarship program are now available from The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio. The booklet also contains information about previous award programs including descriptions of some of the winning papers. Suggested subject matter for student papers and a welding bibliography are given.

Chemical Industries Show

Exhibits covering the production of chemicals, chemical processing, the use of chemical ingredients and chemical steps in connection with mechanical operations of all kinds, affecting many industries, will be featured at the twenty-second exposition of chemical industries to be held November 28 through December 3 in New York. The exposition is under the management of the International Exposition Company.

Magnolia Purchasing Agents

J. V. Mills and Herman Iles have been appointed assistant purchasing agents for the refining division at Beaumont, Texas, of Magnolia Petroleum Company. J. V. Mills was transferred to the purchasing department from his position as assistant to the manager of the industrial relations department. Herman Iles was formerly administrative clerk in the purchasing department.

Dr. Burrill Joins Creole

Dr. C. L. Burrill has been elected to Creole Petroleum Corporation's board of directors. Formerly head of the budget department of Standard Oil Company (New Jersey), he joined Creole in August. A civil engineer, accountant and petroleum economist, Dr. Burrill joined Standard Oil Company (New Jersey) in 1940, formerly serving as assistant professor of accounting at the Harvard Business School.

Phillips-Wasatch Merge

Wasatch Oil Company has merged with Phillips Petroleum Company, the former's present parent company. This merger, which has been in process for more than two years, was completed November 1 by Phillips Petroleum Company's acquisition of Wasatch assets.

Union Oil Elects Linden

Roy Linden has been elected a vice president of Union Oil Company of California. He will continue as manager of sales. He joined the company in 1916, as a plantman and warehouseman.

Shell Economist Resigns

Employed with the company for almost 27 years, Joseph H. Salmon, Shell Oil Company economist and assistant to the president, has resigned. The company has not named a successor to Salmon, who is also a member of the Interstate Oil Compact Commission's economic advisory committee.

Diamond Anniversary

In celebration of its diamond anniversary the Colorado School of Mines held a three-day observance in Golden, Colo., conferring honorary doctor of engineering degrees upon Julius A. Krug, secretary of the interior, Dr. M. F. Coolbaugh, Colorado School of Mines president emeritus; and Dr. Carey Croneis, president of Beloit College, Beloit, Wis.

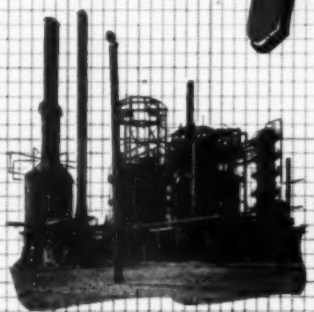
Wins Safety Award

Continental Oil Company emerged with first place awards in two departments of the National Safety Council's annual safety contest between U. S. major oil companies. The company won first in marketing and production.

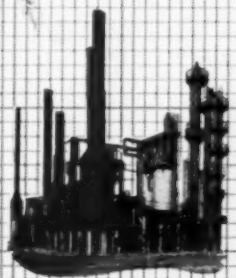
Gulf's New Accountants

Gulf Oil Corporation has named Wiley G. Robinett assistant comptroller, succeeding John A. Ellen, who is retiring; Adam P. Yung, manager of sales accounting; and E. F. Franz, budget director.

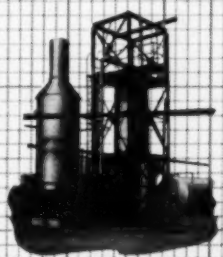
7 "life-saving" PERCO* UNITS engineered by KOCH



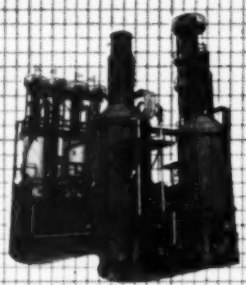
WOOD RIVER OIL & REFINING CO., INC., Hartford, Ill.—10,000 B/D Straight Run and Cracked Gasoline Reforming and Gas Oil Cracking.



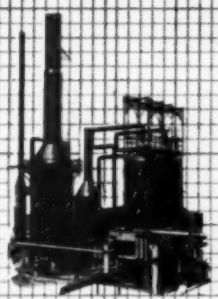
BARECO OIL COMPANY, Wichita, Kansas—4,000 B/D Straight Run and Cracked Gasoline Reforming.



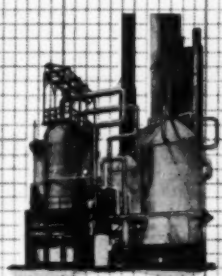
M. F. A. OIL COMPANY, Chanute, Kansas—700 B/D Straight Run and Cracked Gasoline Reforming.



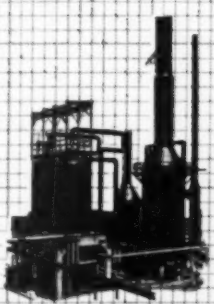
ROOSEVELT OIL & REFINING CORP., Mt. Pleasant, Michigan—3,000 B/D Straight Run Gasoline Desulfurization Reforming.



KANOTEX REFINING COMPANY, Arkansas City, Kansas—4,200 B/D Straight Run and Cracked Gasoline Reforming.



NATIONAL COOPERATIVE REFINERY ASSOCIATION, McPherson, Kansas—5,000 B/D Straight Run and Cracked Gasoline Reforming.



SHALLOW WATER REFINING COMPANY, Shallow Water, Kansas—1,000 B/D Straight Run and Cracked Gasoline Reforming and Gas Oil Cracking.

7 refiners are using these "life-saving" Perco units to keep in the octane race. A Perco unit will upgrade the Research octane of either sweet or sour straight run gasoline by 10 to 15 points with comparatively little loss. You will be surprised at the low cost of a Perco unit that will fit your needs.

Write or wire us today without obligation.

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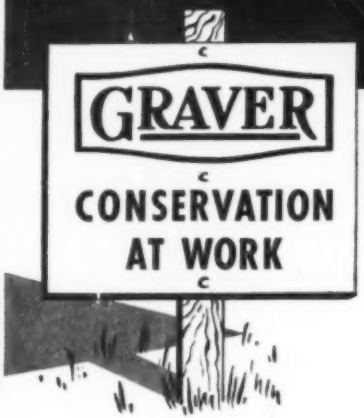

Graver equipment at the Jones Island (Milwaukee) Terminal includes four cone roof tanks and an Expansion Roof Tank with a total capacity of 10,206,000 gallons.

at SHELL'S MILWAUKEE TERMINAL

• Safe gasoline storage and prevention of vapor losses are insured by the use of a Graver Expansion Roof Tank manifolded with four Graver Cone Roof Tanks at Shell's new marine terminal at Milwaukee.

This is Shell's largest postwar construction in a chain of new or expanded distribution centers and the importance of conservation is pointed up by the size of the operation. About 42,000,000 gallons of regular and premium gasolines, domestic heating oil, and prime white will pass through the terminal every year.

You are urged to inspect the economic advantages of the Graver Expansion Roof — its record of savings of salable products and its *proven* features of safety, positive action, and freedom from maintenance. For complete and convincing case histories, get in touch with Graver at once.

GRAVER

FABRICATED PLATE DIVISION

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SCIENCE and TECHNOLOGY Abstracts

Prepared by
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The Leslie Laboratories
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These abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also will be prepared and furnished by arrangement with the Laboratories.

Fundamental Physical and Chemical Data

Viscosity of Normal Paraffins Near the Freezing Point. E. B. GILLER AND H. G. DRICKAMER. *Ind. Eng. Chem.*, **41** (1949) pp. 2067-9.

The viscosities of a series of normal paraffin hydrocarbons were measured over a temperature range down to the freezing point and into the supercooled region. The results show that the free energy of activation per unit volume is substantially independent of temperature except at the freezing point and below where an increase is noted, probably caused by increased molecular orientation. A relation is shown between freezing points of compounds and freezing point viscosities.

The Molecular Adsorption Areas of Hydrocarbon Gases on Charcoal. M. A. NAY AND J. L. MORRISON. *Can. J. Research*, **27B** (1949) pp. 205-14.

The low-temperature adsorptions of methane, ethane, propane, butane, isobutane, ethylene, acetylene, and nitrogen on a series of coconut charcoals of different degrees of activity were determined. Langmuir isotherms were obtained and the measurements indicated horizontal orientation of the hydrocarbon molecules on the charcoal surface. A molecular adsorption area was assumed for nitrogen, and by comparing the gas adsorbed with nitrogen adsorbed, average adsorption areas were calculated for the other hydrocarbons. These values are given.

The Surface Tension of Oils. ALFRED HALPERN. *J. Phys. & Colloid Chem.*, **53** (1949) pp. 895-7.

Studies of the surface tension of oils have not been many. The author reviews the literature of the subject briefly. Surface tensions determined by the author were measured by the capillary-rise method and the drop-weight method. Nine oils were studied over a temperature range from 20 to 130° C. Tabulated results indicate that the surface tension of these oils decreases with increase in temperature.

Thermodynamic Properties of Three Isomeric Pentenes. D. W. SCOTT, GUY WADDINGTON, J. C. SMITH, AND H. M. HUFFMAN. *Jour. Am. Chem. Soc.*, **71** (1949) pp. 2767-73.

The heat of vaporization at three temperatures, vapor heat capacities at five temperatures, vapor pressures and normal boiling points, second virial coefficients, and the entropies of the vapors at three temperatures were determined for 1-pentene, 2-methyl-1-butene- and 2-methyl-2-butene. A vibrational assignment was made for 2-methyl-2-butene, and the free energy function, heat content function entropy and heat capacity of this substance were computed for selected temperatures up to 1500° K. by the method of statistical mechanics. Data are presented in detail in the form of ten tables and a bibliography of 29 references is included.

Effective Thermal Conductivities in Gas-Solid Systems. D. G. BUNNELL, H. B. IRVIN, R. W. OLSON, AND J. M. SMITH. *Ind. Eng. Chem.*, **41** (1949) pp. 1977-81.

The paper reports experimentally measured gradients both in the direction of gas flow and perpendicular to it that is, radially, in a 2-inch inside diameter tube packed with 0.125-inch cylindrical alumina pellets. Temperatures were measured for both the solid and gas. The mass velocities of flow were 150 to 500 pounds per hour per square foot. The entering air was maintained at 400° C. and the reactor wall held to about 100° C. by a boiling water jacket. Measurements were made at seven points across the diameter of the reactor and at packed bed depths of 0, 2, 4, 6, and 8 inches. Although important temperature gradients were observed, the solid and gas temperatures were identical within the accuracy of the measurements. Radial heat transfer in a packed bed descends primarily on the characteristics of the gas rather than those of the solid pellets. Effective thermal conductivities computed from the temperature measurements ranged from about 0.1 to 0.4 Btu per hour foot degree. The increase in effective thermal conductivities over the value at static conditions was directly proportional to the mass velocity of the gas.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

2,5-Octadiene
Dodecafluoropentane
Decafluorocyclopentane
Azomethane
Butyl fluoride
3-Methyl-3-amino-4-heptanol
2,3-Dimercaptobutane
2,3-Dimercaptopropyl methyl ether
2,3-Dimercaptopropyl ethyl ether
Dimethyl-2,3,4-trichloroglutarate
Isobutyl peroxide
Senecioic acid
Methyl hydrogen sebacate
Benzene pentacarboxylic acid
Diallyl ketone
Vinyl allyl ketone
Vinyl iodide
Tridecamethylene bromohydrin
2,4-Heptadien-6-one
1,3-Dimethyl-1,3-diphenylcyclobutane

Chemical Composition and Reactions

Relative Reactivity of Olefins. Reactions of Atoms and Free Radicals in Solution. M. S. KHARASCH AND MARVIN SAGE. *J. Org. Chem.*, **14** (1949) pp. 537-42.

It has been suggested that the addition of olefins to polyhalomethanes, α-bromo esters, etc., proceeds in two steps. The relative reactivities of a number of olefins with respect to their abilities to react with free trichloromethyl radicals, was evaluated. The one-to-one products of the following olefins with bromotrichloromethane were prepared; 2,3-dichloropropene-1, alkyl cyanide, methallyl chloride, ethyl vinylacetate, alkylbenzene, 2-ethyl-1-butene, 2-methyl-2-butene, ethyl cinnamate, and cyclohexene. The relative reactivities of 15 olefins towards a free trichloromethyl radical were established.

High-Temperature Oxidation of Hydrocarbons. Observations on the High-Temperature Reaction. M. F. R. MULCAHY. *Trans. Faraday Soc.*, **45** (1949) pp. 537-41.

The slow combustion of hydrocarbons at atmospheric pressure proceeds by one reaction mechanism up to about 300° C., and by another above about 400° C. In the low temperature range, the structure of the hydrocarbon molecule, has a large effect on the reaction rate. Increasing the chain length accelerates the rate. Branching the chain depresses the rate. Formation and subsequent decomposition of peroxides largely govern the course of the reaction. The effect of structural factors on the rate of reaction is much more marked at the low than at the high temperatures. It is regarded as unlikely that the high-temperature reaction is peroxidic in character. At low temperature, the attack on the molecule occurs mainly at CH and at CH_3 groups, but at high temperature the initial attack tends

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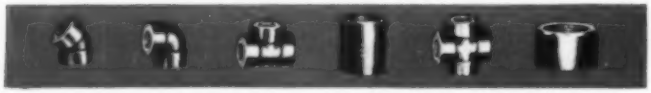

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to occur at the end of the chain, i.e., at a CH_3 group. This probably accounts for the inertness of methane, ethane, and acetone to oxidation at low temperature.

Destructive Hydrogenation of Indan and Hexahydroindan. V. N. Ipatieff, Herman Pines and E. E. Meisinger. *Jour. Am. Chem. Soc.*, **71** (1949) pp. 2685-7.

Destructive hydrogenation of indan and hexahydroindan was studied. With nickel-kieselguhr catalyst, the hydrogenolysis occurs at 240-250° C. The principal products are 1-methyl-2-ethyl- and 1,2-dimethylcyclohexane. Destructive hydrogenation of indan at 325° in the presence of copper oxide-alumina catalyst yielded n-propylbenzene and toluene as the main products. Aromatic hydrocarbons were also formed when hexalhydroindan was destructively hydrogenated in the presence of copper-alumina catalyst.

Preparation of Labelled 1-Butene. Preparation of 1-Butene Labelled with C^{14} in the Four Position. R. B. Regier and R. W. Blue. *J. Org. Chem.*, **14** (1949) pp. 505-8.

One-butene labelled with C^{14} is useful for study of numerous hydrocarbon reactions. The molecule is long enough so that it is typical of the longer chain olefins and can undergo both double-bond and skeletal isomerization. On the other hand, the products can be readily analyzed by infrared absorption. Hydrocarbon 1-butene can be prepared in good yield from methyl alcohol containing carbon-14. The procedure for doing this and the apparatus used are described in detail.

Manufacture: Processes and Plant

Heat Transmission Through Fluidized Beds of Fine Particles. Max Leva, Murray, Veintraub and Milton Grummer. *Chem. Eng. Progress*, **45** (1949) pp. 563-72.

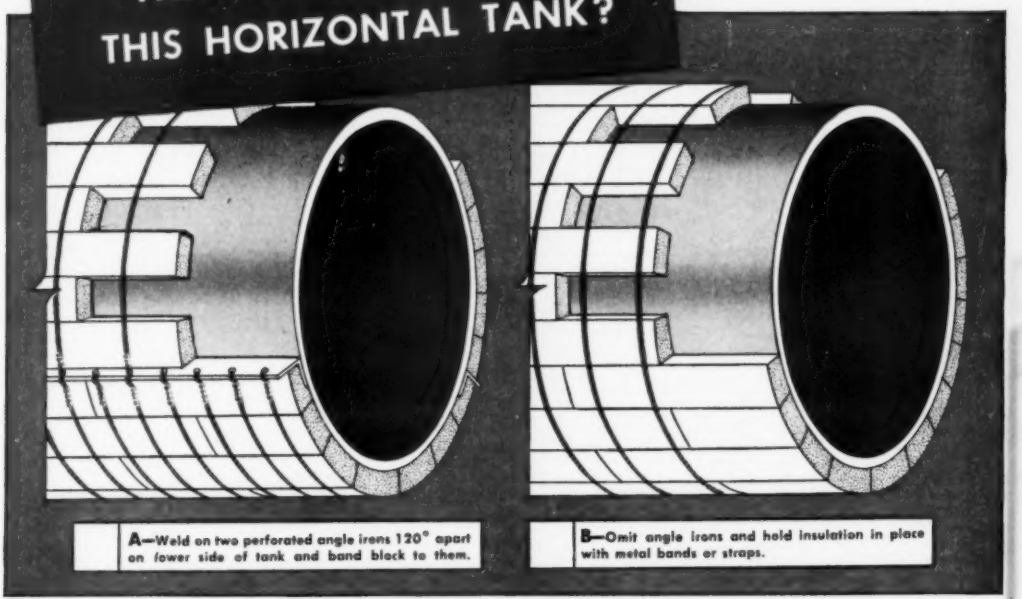
An equation was derived for the calculation of heat transfer coefficients through fluidized beds in terms of characteristic fluidization variables. 2-inch and 4-inch diameter tubes were used with round sand, sharp sand, and an iron Fischer-Tropsch catalyst (Fe_3O_4) in the particle size range 100 to 400 mesh. The effect upon rates of heat transfer of various bed, particle, fluid, tube, and fluidization variables was studied. The application of the equation to the design of reactors utilizing fluidization is discussed. Within the limits of the experimental data it was shown that the bed height, the concentration of solids in the bed, the density of the solid phase, and the vessel diameter had no effect upon heat transfer. The effect of slugging upon heat transfer was found to be negligible. Channeling, however, had a pronounced effect. Absolute particle size and shape are more important than size distribution in causing channeling.

Fluid Flow Through Granular Materials. A. R. Morcom, B.A., D.Sc. *Trans. Inst. Chem. Engrs.* (London), **24** (1946) pp. 30-43.

Previous work on the flow of fluids through granular beds is critically reviewed. The author concludes that data hitherto published are insufficient to per-

HOW WOULD YOU ATTACH HEAT INSULATION TO THIS HORIZONTAL TANK?

● Horizontal tank 6′ in diameter is to be insulated with 2″ thick 85% Magnesia block. Which of the two methods illustrated would you recommend?



A—Weld on two perforated angle irons 120° apart on lower side of tank and band block to them.

B—Omit angle irons and hold insulation in place with metal bands or straps.

HERE'S WHAT THE ARMSTRONG ENGINEER RECOMMENDED:

Both methods shown above will hold the insulation on a 6′ tank firmly in place. But on a tank this size, it is unnecessary to go to the extra expense of welding on and perforating the angle irons. The Armstrong engineer recommended the less expensive Method B.

However, on very large tanks, or where extreme vibration conditions are encountered, it is often necessary to additionally support the bottom third of the insulation. Then Method A, or some other means of providing extra support to the insulation on the underside of the tank, would be in order.

Many times a piece of heated equipment can be efficiently insulated in two or more ways. In these cases, an engineer or workman well grounded in the application of heat insulation can quickly choose the best method.

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mit accurate calculation of loss in pressure head for any particular flow conditions and bed structure. Studies were made with beds of various types of packing. Fluids used were air, carbon dioxide and hydrogen. Rates of flow up to that corresponding to a modified Reynolds number of 750 were studied. The results are presented in graphical form. It was found that within the range of the study, a two-term equation expresses the relation between flow rate and pressure drop accurately. Results of pressure loss determinations can be correlated by means of a factor proportional to the cube of the percentage void space. Numerical values of the constants in the equation given, are tabulated for various granular materials. Smooth spheres, roughly spherical nodules, and graded, broken coke, all give the same values for these constants if packed into the bed in a standardized manner. It was not found possible to derive a general formula or "shape factor" from which the resistance of some materials to the flow of fluids could be predicted accurately in all cases.

Entrainment and Efficiency in Distillation Columns. H. E. Eduljee, B.Sc., Ph.D., A.R.I.C. *Trans. Inst. Chem. Engrs.* (London), **24** (1946) pp. 128-32.

Entrainment in a distillation column can be predicted by means of an equation given. The author concludes that entrainment as high as 10 percent can be tolerated as far as distillation efficiency is concerned. For the system air-water, 10 percent entrainment is obtained with 12-inch plate spacing at a vapor velocity that just fully opens the slots of the cap. An equation is given for calculating vapor velocity at maximum efficiency, that is, the optimum vapor velocity. A bibliography of ten references is included.

Distillation of an Indefinite Number of Components. John R. Bowman. *Ind. Eng. Chem.*, **41** (1949) pp. 2004-7.

The fundamental equations of distillation theory are generalized to apply to systems composed of an infinite number of components. The results apply to systems of any given number of components, because the elements of the general infinite set are arbitrary and not necessarily all different. The subject is mathematically developed and applied to both continuous rectification and batch distillation.

A New Distillation Packing. M. R. Cannon. *Ind. Eng. Chem.*, **41** (1949), pp. 1953-5.

The packing described consists of small units made from thin metal that has 1024 holes per square inch and is shaped into half cylinders with the corners or edges bent inward to prevent nesting of one piece into another. The holes are not clean, but a protrusion or burr extends from one side. This surface has the unique property of being automatically wetted by liquid hydrocarbons. An important characteristic of the packing is that it wets itself thoroughly when any part of a piece of packing touches a drop of liquid. Consequently, starting time is reduced because it is not necessary to preflood the packing. Tests of the packing in a particular column show that no other packing, except Stedman, is as efficient as the protruded packing. Since it is made from flat metal, a relatively inexpensive starting material, it is less expensive than packings made from wire gauze or from fine wire. The packing is put in place simply by pouring it through a funnel.

Application of McCabe-Thiele Method to Extractive Distillation Calculations. George T. Atkins and Charles M. Boyer. *Chem. Eng. Progress*, **45** (1949) pp. 553-62.

Extractive distillation differs from simple distillation in that an added component of the selective solvent type is present in fairly large amounts, thus favorably influencing the order in which the other components distill, and their relative volatilities. In this instance, the solvent used was a mixture of approximately 85 percent acetone and 15 percent water. The authors present a method of calculation employing the McCabe-Thiele graphical method for making extractive distillation calculations. The method was applied to a study of operating variables which led to maximum recovery of butylenes, determination of plate efficiency in the extractive distillation tower, to the determination of butylene recovery from a variety of feed stocks, and as a basis of the design of additional facilities. Fundamental volatility data for the separation of the various saturated and unsaturated butanes in the presence of acetone as the solvent are presented. Data are also given that indicate clearly the effect of feed rate, reflux ratio, and solvent rate upon the recovery of butylene.

Solvent Fractionation with Immiscible Solvents. Charles R. Bartels and Gerald Kleiman. *Chem. Eng. Progress*, **45** (1949) pp. 589-94.

The authors present a simplified mathematical method for determining the effect of process variables on liquid-liquid fractionation, that is, on fractionation of mixed solutes effected by distribution between immiscible solvents. Material balance equations were derived and plotted as a family of curves from which a graph can be prepared relating recovery and purification with the number of plates and feed point. An example is presented showing the application of the method of calculation. A bibliography of 12 references is included.

Alkylation. R. Norris Shreve. *Ind. Eng. Chem.*, **41** (1949) pp. 1833-40.

The article is part of the second annual Unit Processes Review by Industrial and Engineering Chemistry. Alkylation reactions are classified in terms of the method of bonding the alkyl group into the rest of the molecule. Included are alkyl bonded to oxygen, alkyl bonded to nitrogen, alkyl bonded to carbon, and alkyl bonded to elements such as metals. A bibliography of 190 references is included.

Isomerization. Stephen F. Perry. *Ind. Eng. Chem.*, **41** (1949) pp. 1887-9.

The article is part of the annual Unit Processes Review of Industrial and Engineering Chemistry. Among the subjects covered are the application of isomerism to paraffins, naphthenes, alkylated aromatics, alkyl halides and olefins. A bibliography of 37 references is included.

Pyrolytic and Catalytic Decomposition of Hydrocarbon. Vladimir Haensel and Melvin J. Sterba. *Ind. Eng. Chem.*, **41** (1949) pp. 1914-22.

This article is part of the annual Unit Processes Review and includes the material that has appeared in the literature during 1948 and the early part of 1949. The past year has been noted for the continuation of fundamental experimental work, both in thermal and catalytic decomposition reactions, and the industry has continued its trend toward increasing capacity of catalytic cracking. Included in the subjects covered are thermal cracking, catalytic cracking, catalytic re-forming and dehydrogenation. A bibliography of 109 references is included.

Sweating of Paraffin Wax. John R. Bowman and H. Stanley Burke. *Ind. Eng. Chem.*, **41** (1949) pp. 2008-12.

No theoretical study of the sweating operation has been published and present practice is empirical. The paper presents a mathematical analysis of the operation along lines closely following those developed for some distillation problems. Equations of performance for the sweating operation employed in the manufacture of paraffin wax are derived for the general case of arbitrary initial composition, expressing implicitly the compositions and melting points of the products as functions of the yield, assuming 1) that the components form ideal solutions; 2) that the quenched melting points are mean values; and 3) that the melting points of the individual components are linearly correlated with their respective relative crystallizabilities. For the idealized case treating a continuous series of components uniformly distributed with respect to relative crystallizability, the equations of performance assume a simple form. A theoretical treatment of the effect of the retention of the liquid by the melting cake is also given.

Purification of Five Hydrocarbons by Adsorption. Anton J. Streiff, Beveridge J. Mair, and Frederick D. Rossini. *Ind. Eng. Chem.*, **41** (1949) pp. 2037-8.

The authors describe the purification by adsorption with silica gel of three branched-chain paraffin hydrocarbons, 2,2,3-trimethylbutane, 2,2,4-trimethylpentane, and 2,2,4,4,6-pentamethylheptane, and two isomeric alkyl benzenes, 1,2-diethylbenzene and 1,4-diethylbenzene. The purity of the product obtained was determined by measuring the freezing points. Charts are given showing the freezing point and purity of the product from the adsorption process as a function of its volume. The results confirm the finding of previous work that the fractionating process of adsorption can frequently be used to effect purification to a high degree of purity of compounds that might not be purifiable by other processes of fractionation. The process of adsorption appears to be particularly useful in removing small amounts of isomeric close-boiling impurities from alkylbenzenes and from highly branched paraffin hydrocarbons. A bibliography of 11 references is given.

Products: Properties, Utilization and Analysis

Viscosity, Temperature, and Pressure of Lubricating Oils. R. T. Sanderson. *Ind. Eng. Chem.*, **41** (1949) pp. 2059-61.

The similarity between cooling and compression, in their effect of increasing the viscosity of liquids, has long been recognized. However, attempts to correlate viscosity, temperature, and pressure quantitatively in a form conveniently ap-

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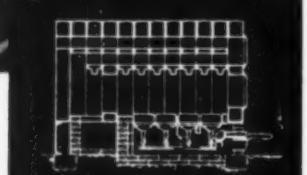

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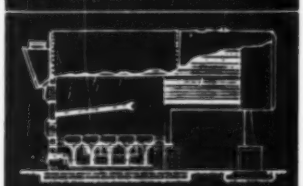

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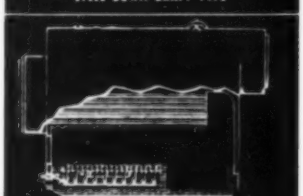

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plicable to lubricating oils have not been entirely satisfactory. A simple relation between kinematic viscosity and pressure and temperature has been found that seems of sufficient promise to deserve careful consideration. An exact equivalence between compression at 100° F. and cooling at one atmosphere pressure, in their effect on the kinematic viscosity of some pure hydrocarbons in the light lubricating oil range, has been found and evaluated quantitatively as a linear relation between $P^{1/2}$ and log T. Data are not yet available for thorough evaluation of the applicability to petroleum lubricating oils, but it appears possible to predict at least approximately the effect of pressure on the kinematic viscosity from a knowledge of the viscosity-temperature properties. The observation that oils having low viscosity-temperature coefficients also have low viscosity-pressure coefficients is quantitatively confirmed.

Representation of Viscosity-Temperature Characteristics of Lubricating Oils. J. H. RAMSER. *Ind. Eng. Chem.*, **41** (1949) pp. 2053-9.

Next to viscosity level, the true variation of viscosity with temperature is the most important property of lubricating oils. On the basis of a general functional relation between viscosity and temperature, it is shown by mathematical reasoning that the viscosity index and the ASTM slope are not unique measures of the fractional change of viscosity with temperature for the reason that viscosity enters the derived relations as an independent variable. The properties of the average fractional change of viscosity, calculated over comparable sections of the viscosity-temperature curve and between constant temperature limits, respectively, are considered. Comparable sections are defined on the basis of the mathematical notion of curvature. The point at which the curvature of the viscosity-temperature curve is a maximum was calculated for a wide range of oils. It was found that the absolute change of viscosity with temperature has a constant value at this point. A measure of viscosity-temperature characteristics, viscosity-temperature rating, is proposed for evaluation of oils under actual operating conditions. A quantity called the viscosity-temperature rating is proposed as being suitable as a method of rating lubricating oils for practical purposes. Properties of the viscosity-temperature rating are clearly stated.

Apparatus for Quantitative Separation of Butadiene from Its Dimer. JAMES L. JEZL AND CHARLES P. HABLITZEL. *Analytical Chem.*, **21** (1949) pp. 1046-9.

A procedure is described that permits quantitative removal of the dimer 4-vinyl-1-cyclohexene from butadiene without changing the concentration of C_4 hydrocarbons present in small amounts in the butadiene fraction. The sample is charged into a simple column and distilled rapidly with little reflux until vapors no longer come over. The packing is dried by brief standing at room temperature, and the condensed overhead vapors are used for tests requiring a sample free from dimer. The residue can then be analyzed for the dimer and other nonvolatile substances. The column is adaptable to other sepa-

rations of similar kind in which small concentrations of relatively high boiling material are to be removed from volatile samples.

Determination of Butadiene Dimer (4-Vinyl-1-Cyclohexene) in 1,3-Butadiene. Bromination Method. CHARLES P. HABLITZEL AND JAMES L. JEZL. *Analytical Chem.*, **21** (1949) pp. 1049-52.

The accurate determination of the dimer 4-vinyl-1-cyclohexene in 1,3-butadiene is required not only for determining the purity of the butadiene but for controlling an impurity considered detrimental to the quality of polymerization grade butadiene. A method for the accurate and rapid determination of the dimer was developed. The procedure includes a physical separation of the dimer from the volatile hydrocarbons by a rapid distillation of the sample, utilizing a small, simply designed fractionating column with chloroform added as a chaser. The dimer is retained in the chloroform residue. Butadiene is completely expelled. The residue is brominated in glacial acetic acid and the excess bromine determined. Inhibitors present do not interfere. Typical results of synthetic mixtures are given.

Analysis of Gases by Absorption and Combustion Convenient Apparatus and Procedures. FRANCIS R. BROOKS, LOUIS LYKKEN, WILLIAM B. MILLIGAN, HAZELTON R. NEBEKER, AND VICTOR ZAHN. *Analytical Chem.*, **21** (1949) pp. 1105-16.

The authors note that published information is widely scattered, the textbooks covering the subject do not give complete details of methods and frequently do not present modern practice. The methods given in the article are a result of study of industrial gas analysis over a period of years. Improved methods and apparatus are described for the analysis of fixed and hydrocarbon gases by progressive absorption and combustion. The apparatus is built in unit sections that can be assembled in various combinations. A mercury lift is used to give definite control of gas displacement and eliminates the use of heavy leveling bulbs. A constant-pressure reservoir confines the gas during the complete cycle passages and automatically maintains constant pressure without the use of manually operated leveling bulbs. Ball and socket joints display rubber tubing. The use of precipitated copper oxide containing 1 percent iron oxide for the determination of paraffins by combustion at 700° C. without the addition of air or oxygen is an innovation. Three methods are described for the analysis of gas mixtures frequently encountered in the petroleum industry. The first combines combustion and absorption procedures for determining acid gases, oxygen, nitrogen, hydrogen, carbon monoxide, acetylenes, ethylene, isobutylene, other mono-olefins and paraffins. The second method covers the determination of alkyl acetylenes, 1,3-butadiene, isobutylene, normal butylenes, and butanes in C_4 hydrocarbon mixtures by use of selective absorption. The third method gives a procedure for the determination of conjugated diolefins, alkyl acetylenes, tertiary olefins, residual olefins, and pentanes in C_5 hydrocarbon mixtures by selective absorption from the vaporized sample. The article is well illustrated

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HELICOID developed the K-Monel Bourdon tube to give better and longer gage service—to eliminate trouble—to reduce cost. Helicoid K-Monel gages are guaranteed accurate to ½ of 1%. They stay accurate longer.

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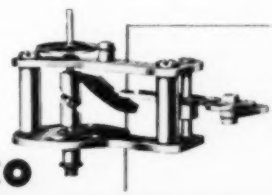

Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
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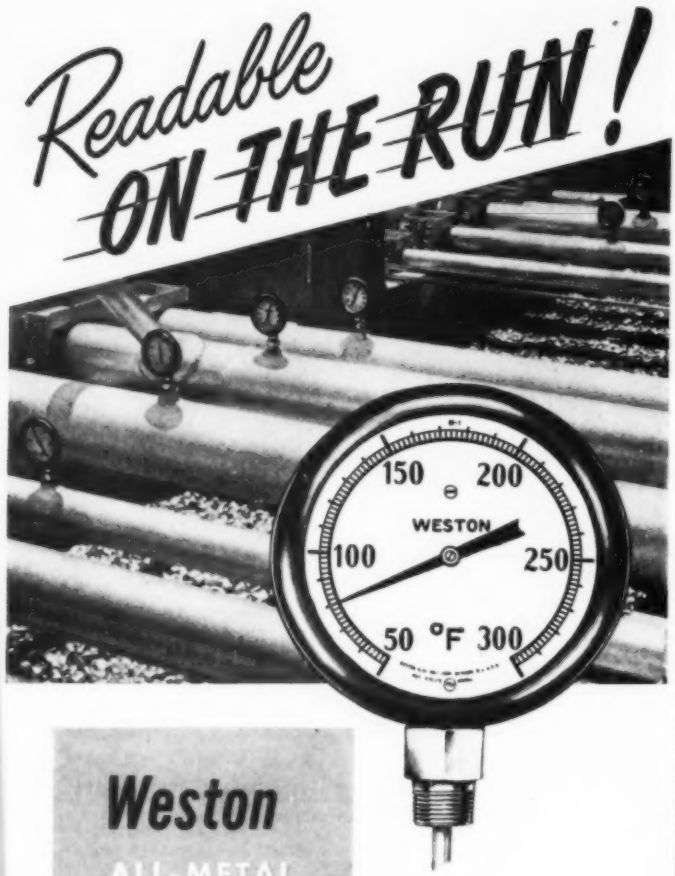
TRADE MARK



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Only a glance is necessary to read the WESTON wide open, bold-faced dial . . . accurately. This readability, combined with rugged, all-metal construction, assures long-time dependability. There's a WESTON thermometer for most industrial applications . . . in a wide variety of types, stem lengths and scale ranges. Call your jobber, your local WESTON representative, or write for Thermometer Catalog . . . WESTON Electrical Instrument Corporation, 655 Frelinghuysen Ave., Newark 5, New Jersey.

CONTACT MAKING models for alarm or control purposes.
MAX-MIN models to indicate highest or lowest temperature reached.

WESTON Instruments

with diagrams and sketches showing constructional details and assemblies of apparatus. Typical results are presented. A bibliography of 55 references is included.

DeLaval Handbook Offers Steam Turbine Engine Data

An engineering handbook for users of pumps, turbines, compressors, and gears has been compiled by the engineering staff of The DeLaval Steam Turbine Company to facilitate the work of power plant, industrial and design engineers. The book is divided into six main sections which give reference data, information and formulas. A general section gives mathematical, mechanical and fluid information of a general nature applying to more than one of the other five sections, which include steam turbine data; centrifugal pump data; Imo pump data; compressor, blower and exhauster data; helical reduction gear data; and worm reduction gear data. Diagrams, tables, photographs, graphs and sketches accompany the data.

Copies of this handbook are available at $2.00 each from the Advertising Department, DeLaval Steam Turbine Company, Trenton 2, N. J.

Refinery Waste Disposal Problem Treated by API

Section 1 of the API manual on Disposal of Refinery Wastes is available in its fourth edition. Discussed is the problem of helping the refiner prevent the escape of oil from his premises, especially waste water containing oil. Incorporating the latest designs of waste separators and explaining the filtration of wastes, the manual describes treatment of emulsions, sampling and testing, measuring waste water flow, and handling ballast water pumped from ships into refinery disposal facilities.

J. A. McNally, API, 50 West 50th Street, New York 20, $2.00.

Sales Writer Promoted

L. F. Van Houten, writer in the sales technical service department of Standard Oil Company (Indiana), has been promoted and transferred to the company's public relations department. Before he joined Standard Oil (Indiana) in 1948 Van Houten was account manager with Bozell and Jacobs Advertising Agency.

Foreign Shipping Manager

L. R. Owen has been named manager of the foreign shipping department of Socony-Vacuum Oil Company, Inc., succeeding the late J. T. Lockwood. H. R. Arnold, general manager of the company's Levant division, will succeed Owen as a member of the foreign trade committee in charge of Turkey and Greece.

Fire Closes Refinery

Due to an estimated $250,000 fire damage last month, Bradford-Penn Refining Company's refinery at Warren, Pa., has been shut down. The refinery's distillation and treating departments were almost destroyed.

COPPER ALLOY BULLETIN

CONDENSER AND HEAT EXCHANGER TUBING EDITION

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

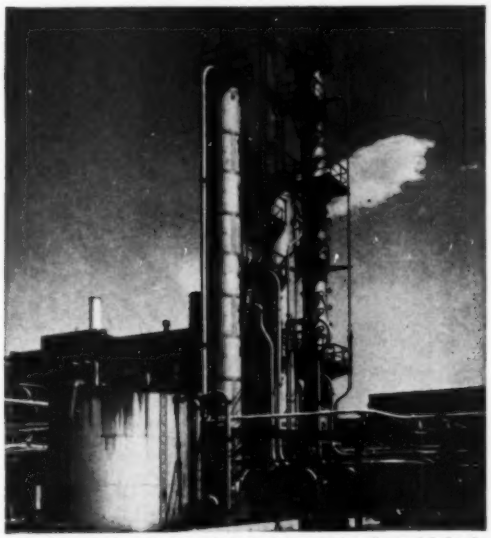
Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

POOLED EXPERIENCES FIGHT CORROSION

Service, Field and Laboratory Work to Solve Problems

Problems involving the handling of corrosive material in chemical and petroleum refining plants are being clarified through the pooling of information from service, field and laboratory reports and tests.

Each of three methods of corrosion testing – service, field and laboratory – has its own peculiar merits and shortcomings. This is especially true of the laboratory and field corrosion tests, which frequently are difficult to correlate with service tests. It must not be assumed that these two methods of corrosion testing have no value, since properly conducted and interpreted field or laboratory tests give an engineer much valuable information concerning the relative corrosion resistance of a metal or alloy.



Years of study and experience are in back of the selection of materials for the naphtha recovery plant of Standard Oil of N. J.

Information concerning the corrosion resistance of metals in service may be obtained from: (1) engineering records concerning a given application of a known material under a known set of conditions; (2) the construction of a pilot plant or test unit made of materials under consideration; and (3) substitution or replacement of corroded parts with a promising material.

Sometimes engineering records cannot take into account the possible effect of: any changes in design, an increase in liquid or gas velocities, temperatures or pressures, known or unknown changes in the composition of liquids, gases, steam, water or materials of construction or the presence of stresses. Occasionally an apparent exact duplication of a unit may fail to perform as expected because of a change in only one of the numerous factors which influence the corrosion rate of a standard engineering alloy.

The obtaining of information concerning corrosion resistance is only carried out by close cooperation with the designing and service engineers and the manufacturer of the materials used in construction. This pooling of thoughts and experiences of men with widely differing backgrounds has made it possible to list various mediums and the alloy which will effectively handle them.

Hydrocarbons... In the purified form, liquid hydrocarbons are virtually non-corrosive to all copper alloys. This is also true of such gases as butane and propane. Where sulphur compounds are present in these products, alloys with lower copper content are generally more satisfactory, i.e., Muntz Metal, Naval Brass and Admiralty.

Acetic Acid... Copper has been widely used for handling acetic acid and acetates. However, under certain conditions, 70-30 Cupro Nickel has been found even more satisfactory.

Alcohols, Glycols, and Esters... Are handled very satisfactorily by copper, Duronze IV (No. 53 aluminum bronze), Aluminum Brass, Admiralty, etc.

Gases... Fluorine, Freon, hydrogen, nitrogen and oxygen have been handled well by Copper, Aluminum Brass, Admiralty, 70-30 Cupro Nickel, etc., at atmospheric and subatmospheric temperatures.

Halogen Derivatives (chlorinated organic compounds) ... In the absence of moisture, these are handled successfully by all copper-base alloys. In the presence of moisture, increased corrosion may be encountered. No. 632 Silicon Bronze, No. 609 Silicon Bronze, Red Brass, etc., are preferred.

Hydrofluoric Acid... 70-30 Cupro Nickel has shown good corrosion resistance to aqueous hydrofluoric acid solutions and anhydrous hydrogen fluoride.

Salt Solutions... Non-oxidizing salt solutions are generally handled very satisfactorily by copper and copper-base alloys. Where the velocity is high, such alloys as Duronze IV (No. 53 aluminum bronze, 95% copper, 5% aluminum), 70-30 Cupro Nickel and Aluminum Brass, are preferred.

Sodium Hydroxide... In the absence of sulphides, 70-30 Cupro Nickel shows excellent resistance to sodium hydroxide.

Sulphuric Acid... Copper-base alloys show good corrosion resistance to sulphuric acid and phosphoric acid, in the absence of oxidizing agents. In such applications, the Silicon Bronzes No. 632 and No. 609 are recommended.

Ammonia Refrigeration... and numerous other chemical processes where double corrosive conditions exist, Duplex Tubing is widely used. Bridgeport offers its extensive experience and laboratory facilities to assist in solving your corrosion problems.

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BRIDGEPORT BRASS COMPANY, BRIDGEPORT 2, CONN. • *ESTABLISHED 1865*

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Crude Oil, Natural Gasoline and Liquefied Petroleum Products

Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, August 16, 23, 30 and September 6, 1949)

REFINING

U.S.P. 2,479,108. Fractional Distillation. C. G. Gerhold to Universal Oil Products Company.

A fractionating tower is claimed which accomplishes improved flow through the column by a centrifugally whirling contact between the upflowing vapor stream and the downflowing condensate.

U.S.P. 2,479,326. Antiknock Motor Fuel. P. L. DeVerter to Standard Oil Development Company.

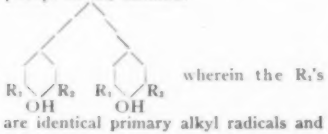
A hydrocarbon base stock within the gasoline boiling range consisting essentially of a hydrogenated copolymer of a normal olefin with 2-6 C atoms and an iso-olefin with 4-5 C atoms is compounded with a lead alkyl antiknock agent and a small amount of hydroxy benzoic acid, its esters, or salts. This additive stabilizes the motor fuel obtained against deterioration during storage.

U.S.P. 2,479,900-3. Antiknock Mixtures. G. Calingaert and J. S. Wintringham to Ethyl Corporation.

An antiknock composition consists of a lead antiknock compound and an amount of a scavenger sufficient to reduce the deposition of lead in the engine by forming volatile lead compounds. A principal active ingredient of the scavenger is either 1) a bromo-hydrocarbon with 2-3 Br atoms and 3-8 C atoms, having not more than one Br atom attached to any C atom and having a vapor pressure at 50° C. of 0.2-6 mm. Hg (U.S.P. 2,479,900); or 2) a mono-bromo-alkylbenzene with 8 C atoms, and the Br atom attached to the benzene ring (U.S.P. 2,479,901); or 3) a dibromoalkane with 4-5 C atoms (U.S.P. 2,479,-902); or 4) a chlorinated aromatic hydrocarbon with 6-8 C atoms and 2-3 Cl atoms attached to the benzene ring, and a vapor pressure as at 1) (U.S.P. 2,479,903.)

U.S.P. 2,479,948. Stabilized Composition. D. B. Luten, Jr., and A. De Benedictis to Shell Development Company.

A cracked gasoline is stabilized by the addition of an alkylated dihydroxydiphenyl of the formula.



wherein the R_1's are identical primary alkyl radicals and the R_2's are identical alkyl radicals which may or may not differ from the R_1's. The two R_1's can also be attached instead to one of the benzene rings and the two R_2's to the other. Examples of the additive are: 3,5,3',5'-tetramethyl-4,4'-dihydroxydiphenyl, and 3,3'-diethyl-5,5' di-tert-butyl-4,4' dihydroxydiphenyl.

U.S.P. 2,480,242. Purification of Naphthene Hydrocarbons. A. E. Hirschler to Sun Oil Company.

A liquid mixture of a major amount of a naphthene hydrocarbon and a minor amount of a straight chain paraffin hydrocarbon is filtered through a body of activated carbon on which the paraffin is selectively adsorbed. The filtrate contains the naphthene in pure form.

U.S.P. 2,480,652. Extractive Distillation of Alcohol-Hydrocarbon Mixtures. C. A. Hillman, J. D. Long, and A. K. Scott to Standard Oil Development Company.

Olefin and paraffin hydrocarbons are recovered from a mixture which also contains higher boiling materials including alcohols and alkyl sulfates from a sulfuric acid treatment by steam distillation and fractionation of the remaining distilled mixture in the presence of a selective solvent under such conditions that the solvent remains in the liquid phase. The vapor fraction contains predominantly paraffins while the liquid fraction contains mostly olefins. These fractions are further treated for the recovery of the separated olefins and paraffins.

U.S.P. 2,480,670. Two-Zone Fluidized Destructive Distillation Process. E. B. Peck to Standard Oil Development Company.

Roughly ground shale containing lumps up to ½ inch in diameter and finely divided material is continuously discharged into a vertically expanding distillation zone and heated therein to release valuable hydrocarbons. A gas is introduced into this zone near its bottom during the distillation operation so that a dense phase ebullient, fluidized mass of shale is formed. Spent shale is continuously withdrawn from the distillation zone and is then suspended in an oxygen-containing gas and subjected to oxidizing conditions to cause the combustion of carbonaceous matter and increase the temperature of the spent shale. At least a portion of the burnt shale is returned to the distillation zone to supply heat thereto. The process can also be used for the treatment of other oil-bearing sands or minerals.

U.S.P. 2,480,919. Recovery of Styrene by Azeotropic Distillation. R. B. Greene to Allied Chemical & Dye Corporation.

An oil containing styrene and at least one like-boiling aromatic hydrocarbon is fractionally distilled in admixture with methyl or ethyl lactate or methyl gylcolate. An azeotrope distillate is obtained which contains at least a part of the non-styrene aromatic hydrocarbon, and an oil with substantially increased styrene content is recovered.

U.S.P. 2,481,207. Method of Dehydrofluorination with Copperplated Metal Catalysts. J. F. Eberle to Phillips Petroleum Company.

Hydrocarbon material containing organically combined fluorine, as, for example, obtained in the alkylation of isoparaffins with an olefin in the presence of a hydrogen fluoride catalyst, is contacted with a copperplated iron catalyst.

U.S.P. 2,481,208. Method of Dehydrofluorination with Metallic Mixtures as Catalyst. J. F. Eberle to Phillips Petroleum Company.

The process according to this patent differs from that of patent 2,481,207 essentially in that the catalyst comprises a solid polymetallic mixture of elementary metals active in the decomposition of organic fluoro compounds without changes in the organic material, e.g. a mixture of finely divided iron and copper.

U.S.P. 2,481,300. Process for Purifying Hydrocarbons. W. F. Engel to Shell Development Company.

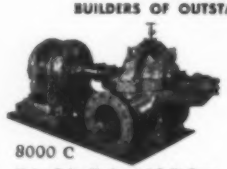
Organically combined halogen is removed from hydrocarbons by contacting the hydrocarbons at a temperature of 250-475° C. under anhydrous conditions with a catalyst consisting of active carbon in combination with an alkaline compound of an alkali or alkaline earth metal. The halogen impurities are retained in the catalyst.

U.S.P. 2,481,439. Gas-Solids Contacting Apparatus Including Means for Stripping Solid Particles. H. J. Ogorzaly to Standard Oil Development Company.

Details are claimed of an apparatus for contacting finely divided solids with gases. The apparatus is provided with a plurality of cellular cartridges or inserts spaced apart to provide unobstructed spaces for redistribution of the solid particles and the gas. Channeling of the solids and gas streams is effectively prevented.

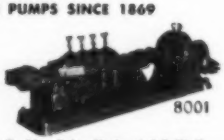
PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869



8000 C

Motor Drive Horizontal Split Case Double Suction Centrifugal Pump

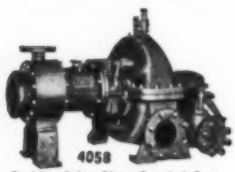


8001

Turbine Drive Horizontal Split Case Multi Stage Centrifugal Pump

4049 A

Two Stage Close Coupled Centrifugal Pump



4058

Turbine Drive Close Coupled Centrifugal Pump

942

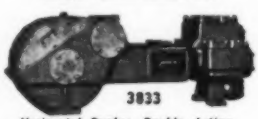
Single Style, Packed Piston Pattern Steam Pump

2352 B

Durable Duplex, Outside End Packed, Plunger Pattern Steam Pump

3918

Durable Duplex, Packed Piston Pattern Steam Pump



3833

Horizontal Duplex, Double Acting, Side Pat, Piston Type, Oil Bath Power Pump

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

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323 W. TENTH ST

Patents

CATALYST PREPARATION, ACTIVATION AND REGENERATION

U.S.P. 2,478,899. Reactivation of Catalysts in Hydrocarbon Synthesis. E. L. d'Ouville to Koppers Company, Inc.

A periodic group VIII catalyst employed in the Fischer-Tropsch synthesis while suspended in the carbon monoxide-hydrogen gases at a temperature of at least 180° C. and with formation of an active metal carbide layer on its surface is removed from the synthesis zone after reduction of its catalytic activity to about 30 percent and introducted into direct contact with a hydrogen stream at a temperature of about 50° C. for a period of 0.5-5.0 hours or at a temperature of about 25° C. for 8-50 hours. The catalyst activity is restored without destruction of the carbide layer.

U.S.P. 2,479,109. Alumina-Platinum-Halogen Catalyst and Preparation Thereof. V. Haensel to Universal Oil Products Company.

A catalyst useful, for example, in hydrocarbon conversion and reforming, is produced by combining alumina with 0.1-8 percent by weight of a halogen, admixing a Pt-containing solution with this combination, and calcining the material obtained.

U.S.P. 2,479,420. Catalyst Recovery in Hydrocarbon Synthesis Processes. M. A. Segura to Standard Oil Development Company.

A mixture of CO and H_2 containing gases is forced into a fluidized bed of powdered iron catalyst maintained under synthetizing conditions. Iron withdrawn from the reaction zone is quenched and then heated to a temperature of at least incipient fusion in the presence of an oxidizing gas. The catalyst particles agglomerated thereby are ground to a size greater than the powdered iron removed from the reaction zone and then returned to this zone.

U.S.P. 2,479,435. Process of Reducing Iron Group Metal Oxides. H. G. Vesterdal to Standard Oil Development Company.

Oxygen compounds of ferromagnetic iron group metals suspended in a reducing gas at a temperature of 500-1600° F. are reduced. The solids are suspended in a gas and those reduced to a total oxygen content of not more than 5 percent are separated from reduced solids of higher oxygen content by means of a magnetic field. The solids of higher oxygen content are then subjected to a renewed reduction until all of the oxygen compounds are converted into solids of the indicated low oxygen content. Powdered catalysts for the Fischer-Tropsch synthesis are obtained.

U.S.P. 2,479,883-4. Process of Reactivating a Poisoned Silver Surface Catalyst. T. J. West and J. P. West to Allied Chemical & Dye Corporation.

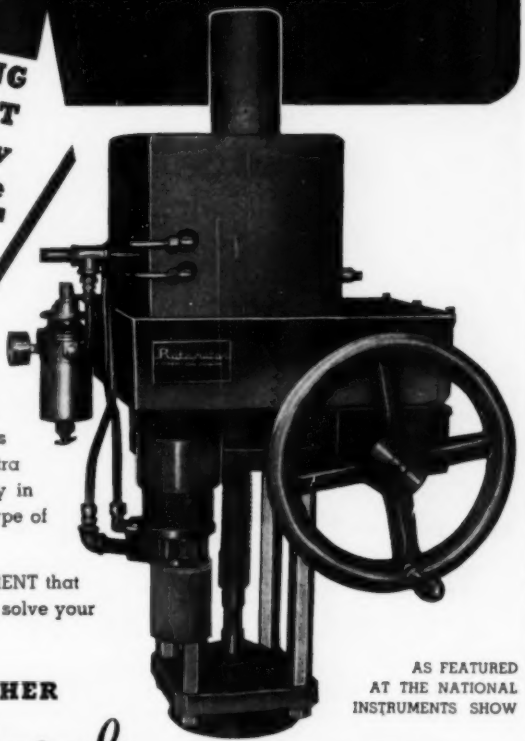
Poisoned silver surface catalysts employed in the direct oxidation of olefins to olefin oxides are reactivated by passing a stream of ammonia and water

NEW! GEAR-DRIVEN PNEUMATIC OPERATOR FOR THROTTLING CONTROL SERVICE

Rotomotor

PNEUMATIC POWER POSITIONING OPERATOR

ACCURATE POSITIONING TO WITHIN 1/500th PART of STEM TRAVEL on Heavy Duty Throttling Service



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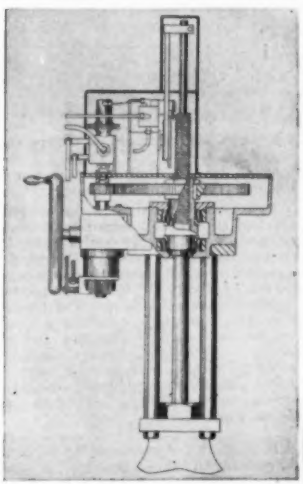

ANOTHER Cono-Controls ACHIEVEMENT

NOTE THESE OUTSTANDING ADVANTAGES—

- Accurate Positioning — within 1/500th part of stem travel.
- Sensitive to instrument output pressure changes as small as .025 psi.
- Rock-like stability — No hunting or cycling.
- Self-locking stem; remains in last position, in case of failure.
- Continuously Connected hand-wheel—eliminates need for by-pass.
- High torque, piston type Motor; low air consumption — operates on 100 psi supply.
- Stem loads up to 10,000 lbs. — travels up to 20".
- Stem speeds — Up to 12" per minute.
- Precision Gear Drive.
- Compact Design—Minimum space and weight.

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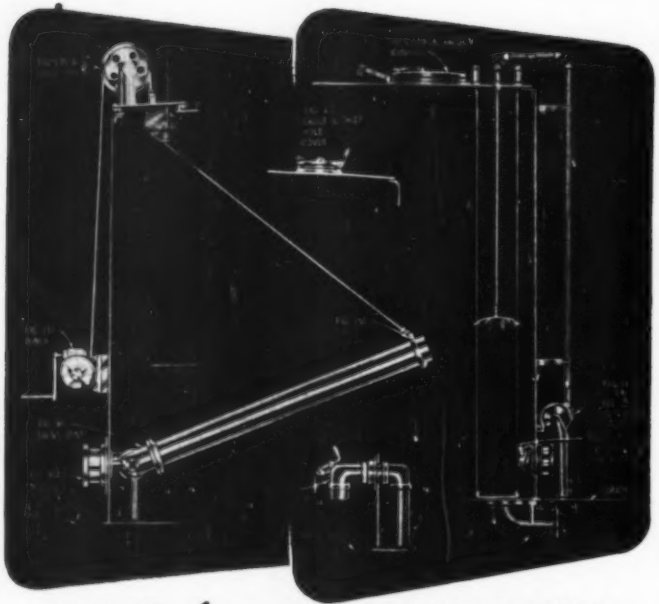
CONOFLOW CORPORATION 2100 ARCH STREET PHILADELPHIA 3, PA.

ACCURATE and RELIABLE

TANK ACCESSORIES
for *Convenient* Operation



"VAREC" *Automatic* TANK GAUGES
and SWING LINE EQUIPMENT

Designed for all types of tanks and corrosive conditions, VAREC Automatic Tank Gauges afford you a safe, accurate, economical means of measuring liquid levels . . . conveniently, and as often as necessary. Gauges operate on a float actuated tape; give reliable readings in an eye-level lookbox outside the tank.

VAREC Swing Line Equipment is especially designed to provide a rapid, convenient method for withdrawal of liquids at various levels. Essentially, it consists of winch and swing joint for raising and lowering of a standpipe.

VAREC gauge hatches, water drawoff valves, drain ells, internal check valves, etc., will safely and reliably complete your tank installation. *Check your needs today.*

CP-12

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COMPTON, CALIFORNIA, U.S.A.

NEW YORK 30 CHURCH ST. PITTSBURGH 719 GULF BLDG. CHICAGO 122 SO. MICHIGAN AVE. TULSA 409 TULSA BLDG. HOUSTON 821A M.B.M. BLDG.
CABLE ADDRESS: VARREC COMPTON (ALL CODES)

Patents

vapor over the catalyst at a temperature of 170-325° C. (U.S.P. 2,479,883), or by passing, before this treatment, a halogen or ethylene dichloride over the catalyst within the same temperature range (U. S.P. 2,479,884).

U.S.P. 2,479,885. Reactivation of Overheated Silver Surface Catalysts. T. J. West to Allied Chemical & Dye Corporation.

The process according to U.S.P. 2,-479,884 can also be used for revivification of overheated silver surface catalysts.

U.S.P. 2,480,341. Catalyst for Carbon Monoxide-Hydrogen Synthesis. H. S. Seelig and J. Zisson to Standard Oil Company of Indiana.

A CO-H_2 mixture is contacted under synthesis conditions at a temperature of 500-600° F. with an iron type catalyst promoted by FeF_2.

U.S.P. 2,480,520. Activated Alumina-Beryllium Oxide Catalyst. C. M. Thacker to The Pure Oil Company.

A catalyst, particularly useful in the dehydrogenation of hydrocarbons, consists of activated alumina and 0.5-30 percent of its weight of beryllium as beryllium oxide.

U.S.P. 2,480,627. Process of Reactivating a Silica-Alumina Cracking Catalyst. E. A. Bodkin and J. M. Johnson to Socony-Vacuum Oil Company, Inc.

Deactivated silica-alumina hydrocarbon conversion catalyst is soaked for reactivation for at least one hour in an aqueous solution containing 1-15 percent alkali metal hydroxide or 10-25 percent alkali metal silicate. After separation, the catalyst is water-washed, and the alkali metal introduced into the catalyst is directly base exchanged with a salt of a polyvalent metal, such as an aqueous solution of an Al, Be, or Zr salt.

U.S.P. 2,480,628. Removal of Zeolytic Alkali from Gels. E. A. Bodkin to Socony-Vacuum Oil Company, Inc.

Dry inorganic oxide gel to be used for catalytic and adsorption purposes is saturated with CO_2 and then washed with an aqueous solution of carbonic acid for a time sufficient to effect substantial removal of zeolytic alkali metal from the gel.

U.S.P. 2,480,669. Process of Preparing Extruded Gels. J. W. Payne, J. M. Johnson, and E. A. Bodkin to Socony-Vacuum Oil Company, Inc.

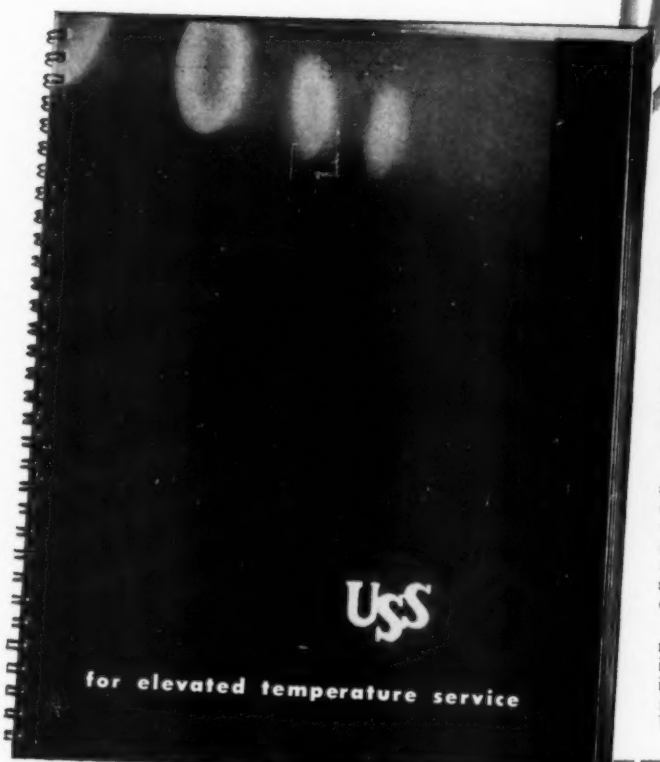
A hydrogel comprising a major proportion of silica and a minor proportion of a hydrous inorganic metallic oxide, such as alumina, is frozen without destroying its colloidal structure at a temperature of about 15° F. by immersion in a water-immiscible liquid. The hydrogel is then thawed to produce a mass of shrunken hydrogel granules and an aqueous liquid. The granules obtained are subjected to extrusion through a die and dried. Hard, porous, adsorbent hydrocarbon conversion catalysts are thus obtained.

U.S.P. 2,480,887. Apparatus for Catalyst Regeneration. L. F. Strader to Hou-

"Steels for elevated temperature service"

A new, authoritative book on this important subject . . .

yours for the asking!



JUST PUBLISHED, this book is the result of 15 years' study of high temperature problems by United States Steel Corporation and its manufacturing subsidiaries.

It is designed to be helpful to engineers, metallurgists and chemists in their quest for suitable structural materials that will maintain adequate strength under the elevated temperatures involved in the power, petroleum, transportation, chemical, and other industries having similar problems.

In its pages are discussed the general principles of behavior of ferrous materials under elevated temperatures, the various factors that influence this behavior, as well as the special testing equipment and laboratory technique used to evaluate the elevated temperature properties of steel.

In the comprehensive data section, the significant property values of *twenty-one* different steels, suitable for use at elevated temperatures, are presented both in tabular and graphical form. Characteristics such as high temperature strength, corrosion resistance, weldability and others are discussed.

Much of the information in this book has never before been published. You'll find it invaluable as a reference if your work involves the operation of equipment that must function at elevated temperature. Use the coupon.

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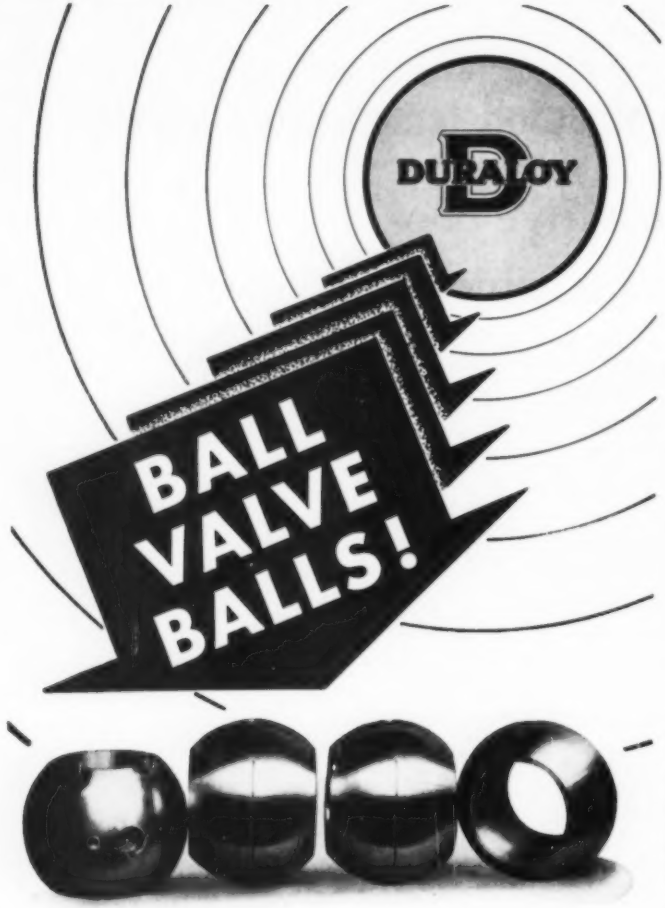

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dry Process Corporation.

The design is claimed of a vertical shaft kiln for regenerating spent pelleted catalyst. Means are provided for achieving uniform downward movement of catalyst through the kiln.

U.S.P. 2,481,226. Two-Stage Reduction Process for Producing Metal Catalyst. R. W. Krebs to Standard Oil Development Company.

Iron oxide and cobalt oxide are reduced in a two-stage operation. An impure hydrogen gas is used in the first stage, and highly purified hydrogen in the second stage. Considerable expense is saved by this method for the production of hydrogenation catalysts. Details of the reducing process are claimed.

U.S.P. 2,481,238. Process of Preparing a Group VIII Metal-on-Aluminum Catalyst. J. A. Pierce and R. W. Richardson to Standard Oil Development Company.

A group VIII metal is precipitated from its aqueous salt solution upon subdivided aluminum by contact of the solution and the aluminum for about 15-30 minutes. The synthesis catalyst thus obtained has high attrition resistant capacity.

U.S.P. 2,481,253. Method of Removing Contaminants from Cracking Catalysts. J. A. Snyder to Standard Oil Development Company.

Finely divided spent silica-alumina cracking catalyst is contacted in a regeneration zone with a hot combustion supporting gas. A substantial portion of the catalyst withdrawn from the regeneration zone is contacted with vaporized CCl_4 under anhydrous conditions at a temperature of 600-1200° F. to remove metallic compounds. The vaporized CCl_4 is separated from the treated catalyst and the latter is returned to the regeneration zone and then recycled to the cracking zone.

CRACKING AND REFORMING

U.S.P. 2,478,916. Reforming Process. V. Haensel and C. F. Gerald to Universal Oil Products Company.

A gasoline fraction is contacted under reforming conditions with a catalyst essentially consisting of a cracking component and Pt- or Pd-metal. The cracking component comprises silica and at least one oxide of Al, Zr, Mg, or Th in an amount of 0.2-2 g. per 100 $cm.^3$ of final catalyst.

U.S.P. 2,479,110. Process of Reforming a Gasoline with an Alumina-Platinum-Halogen Catalyst. V. Haensel to Universal Oil Products Company.

A catalyst comprising alumina, platinum, and combined halogen (as, for example, obtained by the process of U.S.P. 2,479,109) is employed for reforming a gasoline fraction.

U.S.P. 2,480,494. Catalytic Oil Cracking. E. V. Mathy to Phillips Petroleum Company.

High b.p. hydrocarbon oil is contacted in vapor form at cracking conditions

with a catalyst mass comprising calcined bauxite supporting 0.1-5 percent of tin oxide as a promoter. High oxtane gasoline is obtained at a high yield and with minimum carbon deposition.

ALKYLATION

U.S.P. 2,478,897. Prevention of Corrosion in Catalytic Reactions involving the Use of Phosphorus Acid Catalysts. B. B. Corson to Koppers Company, Inc.

An aromatic hydrocarbon is alkylated with an olefin in the presence of a phosphorus acid catalyst at a temperature sufficiently high to set free acid vapors. The conversion products containing these vapors are passed while hot through an adsorbent bed of granular calcined alkaline earth carbonate to remove the acid vapors.

U.S.P. 2,478,900. Process of Rendering Noncorrosive the Products Resulting from Catalytic Alkylation. E. L. d'Ouville to Koppers & Company, Inc.

The process according to this patent substantially differs from that of U.S.P. 2,478,897 only in that the solid adsorbent in the present case is composed of more than 75 percent silica and the remainder alumina.

U.S.P. 2,479,120. Production of Relatively Straight Chain Aykyl Aromatic Hydrocarbons. W. W. Johnstone to Universal Oil Products Company.

An olefinic hydrocarbon fraction boiling at 150-225° C. is treated with H_2SO_4 of 85-100 percent concentration to remove highly branched chain olefins and polyolefins. After removal of the acid the remaining olefinic hydrocarbon fraction is employed for alkylating an aromatic hydrocarbon. Alkyl aromatic hydrocarbons are obtained, the alkyl group of which contains about 9-18 C atoms of relatively straight chain configuration. They are especially useful for the production of detergents.

U.S.P. 2,479,366. Process for the Alkylation of Isoparaffins with Olefins. M. C. K. Jones to Standard Oil Development Company.

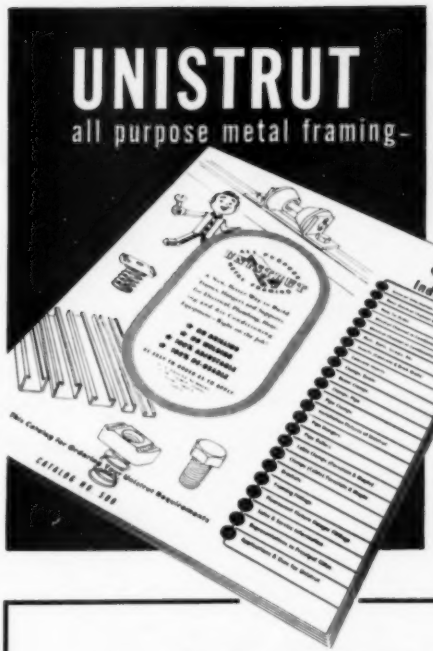
Isoparaffins and olefins are mixed with H_2SO_4 and then subjected under alkylation conditions to a mechanical shearing pressure of 2000-5000 psi. obtained by forcing the mixture through a homogenizing valve.

U.S.P. 2,480,240. Alkylation of Isoparaffins. J. I. Harper to Sun Oil Company.

A C_5 hydrocarbon fraction containing isopentane and amylenes is treated under non-alkylation conditions to provide a portion rich in amylenes and a portion rich in isopentane. The amylene-rich portion is alkylated with isobutane. The octane value of the motor fuel thus produced is materially increased by the preceding selective removal of isopentane.

U.S.P. 2,480,254. Alkylation of Phenolic Compounds Catalyzed by Friedel-Crafts Metal Halides Modified by Boric Acid. J. M. Mavity to Universal Oil Products Company.

A phenolic compound containing a



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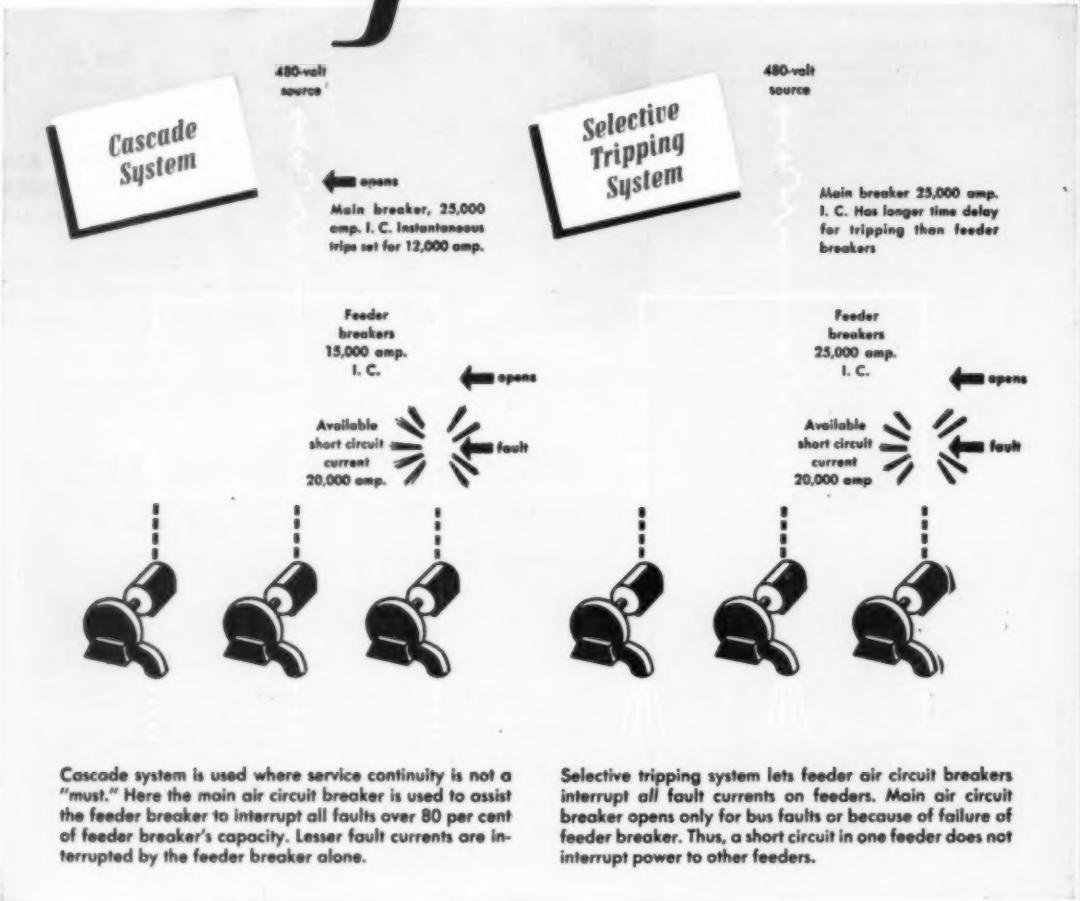
Cascade System
480-volt source
opens
Main breaker, 25,000 amp. I. C. Instantaneous trips set for 12,000 amp.
Feeder breakers 15,000 amp. I. C.
opens
Available short circuit current 20,000 amp.
fault
Selective Tripping System
480-volt source
Main breaker 25,000 amp. I. C. Has longer time delay for tripping than feeder breakers
Feeder breakers 25,000 amp. I. C.
opens
Available short circuit current 20,000 amp
fault

Cascade system is used where service continuity is not a "must." Here the main air circuit breaker is used to assist the feeder breaker to interrupt all faults over 80 per cent of feeder breaker's capacity. Lesser fault currents are interrupted by the feeder breaker alone.

Selective tripping system lets feeder air circuit breakers interrupt *all* fault currents on feeders. Main air circuit breaker opens only for bus faults or because of failure of feeder breaker. Thus, a short circuit in one feeder does not interrupt power to other feeders.

Here's what you need to modernize your power system! }

WHEN YOU COME TO GENERAL ELECTRIC you get far more than the finest in electrical equipment. A General Electric application engineer, familiar with refinery practices, is at your disposal. If desired, he stands ready to take over the job of co-ordinating all the needed components, engineering your power distribution into one modern, efficient system.

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WITH SELECTIVE TRIPPING

—to isolate faults on low-voltage circuits

Although comparatively new, selective tripping of air circuit breakers is becoming increasingly important in the field of low-voltage power distribution. Especially is this the case in applications—such as continuous processing in refineries—that require a high degree of service continuity. By isolating faults at remote points without tripping the main supply breaker, this method eliminates the costly production delays caused by complete power shutdowns.

With selective tripping, full interrupting-rating breakers are used throughout, with differently-timed tripping ranges arranged so that the breaker farthest from the power source trips first. Thus, only that portion of the circuit nearest the fault is isolated. The rest of the power system stays in operation, permits uninterrupted production elsewhere in the plant.

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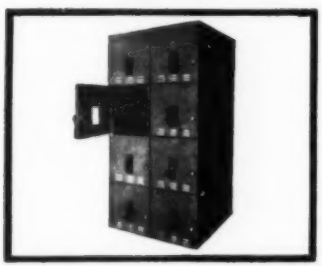
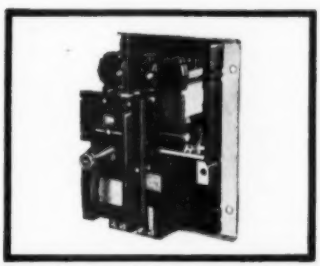


G-E metal-enclosed switchgear, containing air circuit breakers with new trip device, needs less floor space. Features include new rack-out mechanism, improved bus construction.



In the G-E Type AK-1 air circuit breaker (shown here with one trip device removed) you get improved arc interruption, multiple arcing contacts, and interchangeable trip units.

New G-E Type EC-1 tripping device for AK-1 air circuit breakers is sealed to eliminate maintenance, easily adjusted, readily removable for changing trip characteristics.

GENERAL ELECTRIC

661-4

substitutable hydrogen atom attached to the ring is reacted with an olefinic hydrocarbon under alkylating conditions in the presence of a catalyst prepared by reacting boric acid and a metal halide of the Friedel-Crafts type with evolution of hydrogen halide.

U.S.P. 2,480,268. Manufacture of Bicycloalkyl Aromatic Compounds and Hydrocarbons. V. N. Ipatieff and H. Pines to Universal Oil Products Company.

A benzene hydrocarbon having a replaceable nuclear hydrogen atom and a bicycloalkene containing a ring of 6 and a ring of 5 C atoms are reacted under alkylating conditions in the presence of an acid-acting catalyst, such as H_2SO_4. Bicycloalkylbenzene hydrocarbons, such as 2-phenyl-2,6-dimethyl/bicyclo-(3,2,1)-octane, are produced.

PLYMERIZATION AND CONVERSION

U.S.P. 2,479,226. Emulsion Polymerization of Unsaturated Organic Compounds. R. S. George to Hercules Powder Company.

A water-insoluble compound containing the group $CH_2=C<$, e.g. a conjugated butadiene, is polymerized, either for itself or in mixture with another such compound, in aqueous emulsion in the presence of an alkali metal salt of dehydrogenated tall oil as emulsifier.

U.S.P. 2,479,241. Process for Emulsifying Polymerizable Compounds and Effecting Polymerization with Said Emulsions. E. C. H. Kolvoort and G. Akkerman to Shell Development Company.

A water-insoluble liquid compound containing the group $CH_2=C<$ is mixed with an aqueous solution containing about 5-35 percent of an emulsifying agent to form a jelly. This jelly is uniformly mixed under vigorous agitation with sufficient water to form an aqueous emulsion wherein water constitutes the continuous phase. The resulting emulsion is polymerized. The emulsion is very stable.

U.S.P. 2,479,360. Process for Polymerizing Hydrocarbons. F. A. Howard to Standard Oil Development Company.

A reaction mixture containing isobutylene, an inert diluent and a Friedel-Crafts catalyst is continuously introduced into a reaction vessel where a slurry of solid polymer particles in reaction liquid is formed at a temperature below 0° C. Details are claimed for this process of continuously preparing solid polymers with vehement agitation of the reaction mixture.

U.S.P. 2,479,418. Olefin Dimers as Promoters in Low-Temperature Friedel-Crafts Polymerization. H. G. Schutze to Standard Oil Development Company.

Moisture-free isobutylene is mixed with Friedel-Crafts catalyst and unsaturated mono-olefin dimer having 6-8 C atoms in an amount of 14-136 parts per million based on the feed mixture at a temperature of −50° to −175° C. to polymerize the isobutylene. The olefin dimer works as a promoter.

U.S.P. 2,479,618. Low-Temperature Friedel-Crafts Polymerization of Alpha Alkyl Styrenes in Carbon Disulfide Solution. A. B. Hersberger and R. G. Heiligmann to The Atlantic Refining Company.

Alpha alkyl styrenes in which the alkyl group contains not more than 6 C atoms are homo-polymerized by means of a Friedel-Crafts catalyst in the presence of CS_2 at a temperature of +10 to −100° C. A ratio of CS_2 to the alkyl styrene of between 1 and 15 to 1 is employed.

U.S.P. 2,481,273. Isoolefin Polymerization Catalyzed by Friedel-Crafts Double Salts. D. W. Young to Standard Oil Development Company.

An isoolefin with 4-7 C atoms is interpolymerized with a diolefin having 4-14 C atoms by cooling a mixture of such olefins to a temperature of 0° to −160° C. and then effecting polymerization by the addition of a double salt composed of a Friedel-Crafts active metal halide and a Friedel-Crafts active metal oxy halide. This double salt can be dissolved in a hydrocarbon solvent.

HYDROGENATION, DEHYDRATION AROMATIZATION

U.S.P. 2,479,439. Hydrocarbon Synthesis Operation. A. Voorhies, Jr., to Standard Oil Development Company.

CO and H_2 are reacted together under synthesis conditions initially in the presence of an unpromoted powdered Fe,

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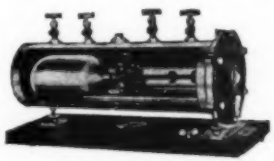

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But in increasing the mass of parts, accuracy and sensitivity are invariably impaired and wear resistance is not necessarily improved. The high impact effect at bearing and other wearing points, which is related to the natural weight of the metal used, *creates wear!* The "products of wear" increase the rate of wear and when carbon particles are exposed, they rust.

The ideal conception of a gauge movement should, therefore, incorporate lightness in parts which move to enhance sensitivity and accuracy of indication and to lessen impact effects on severe service. The "products of wear" should not cause increased wear or be susceptible to atmospheric corrosion. The materials used at bearing and other wearing points should absorb or soften impact. Adequate strength and general corrosive resistance must be provided.

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Aluminum contributes lightness in the mating parts which reduces potential impact to its lowest terms and increases sensitivity. The anodized surfaces enhance the low frictional properties of the aluminum. In contact, the aluminum tends to glaze the nylon which increases the wear resistance and lowers the coefficient of friction. The general corrosive resistance of aluminum is very good. And even in the case of such chemicals as methyl chloride and methyl bromide, which should not be used in direct contact with aluminum base alloys, the Nylon-Aluminum Movement in the Duragauge Vapor Proof case stood up well.

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Patents

Ni, or Co catalyst. A promoter, e.g. KF, is gradually added until the selectivity of the catalyst is increased to produce a product of 180-210 cc. of hydrocarbons with 4 C atoms and higher boiling constituents per cbm. of H_2 and CO consumed. Additional promoter is then added to maintain the catalyst activity in this range. Water is introduced into the reaction zone to repress carbon formation.

U.S.P. 2,479,496. Controlling Catalytic Exothermic Reactions of Gasiform Reactants. F. C. Keith to Hydrocarbon Research, Inc.

In a Fischer-Tropsch synthesis operation under controlled temperature, contact of the reactants with the mass of solid particle catalyst is maintained only until a predetermined portion of the reactants is converted. The resulting effluent stream is withdrawn from the reaction zone with entrained catalyst in a state of exothermic catalytic activity and introduced while at operating temperature directly into a body of solid catalyst particles maintained in a turbulent state of dense phase fluidization in the presence of cooling surfaces subjected to temperature control. The fluidized catalyst is thereby maintained at a predetermined uniform temperature below that of the reaction zone to inhibit activity of the catalyst on the unconsumed reactants. Quenched reaction products are recovered from the fluidized mass. Undesired reactions and impairment of catalyst and products are thus prevented.

U.S.P. 2,479,999. Regeneration of Catalysts Used in the Production of Hydrocarbons from Carbon Monoxide and Hydrogen. A. Clark to Phillips Petroleum Company.

In the Fischer-Tropsch synthesis of hydrocarbons with more than 1 C atom, the catalyst which is deactivated by deposition of high-boiling waxy material during the synthesis is periodically reactivated by increasing the reaction temperature to a point at which the hydrocarbon product consists essentially of methane, while continuing the flow of the CO-H_2-mixture. After removal of the waxy deposit, the temperature is reduced again to that favorable for the production of higher hydrocarbons.

U.S.P. 2,481,089. Process and Apparatus for the Synthesis of Organic Compounds. N. L. Dickinson to The M. W. Kellogg Company.

Details of a process and an apparatus are claimed for the production of organic compounds from CO and H_2 in the presence of a fluidized metal hydrogenation catalyst. The gaseous mixture containing entrained finely divided catalyst is passed under synthesis conditions through a plurality of successive zones while closely controlling operating conditions including the gas velocity in the various zones. The temperature in the first zone shall be substantially lower than that in the last zone.

U.S.P. Re. 23,145. Two-Stage Synthesis of Hydrocarbons. F. T. Barr and W. G. Scharmann to Standard Oil Development Company.

Rigid temperature control is effected in a Fischer-Tropsch synthesis by main-

taining a dense suspension of catalyst in the CO-H_2 gas mixture under synthesis conditions for a period of time limited so that hydrocarbons which are liquid at these conditions are not formed in substantial amounts and that not more than 60 percent of the total possible amount of hydrocarbons are formed. Gaseous reaction material is withdrawn from the suspension and discharged into a zone containing at least one stationary bed of catalyst under reaction conditions to convert additional amounts of these gases into normally liquid products which are recovered.

DESULFURIZATION

U.S.P. 2,479,238. Treatment of Sulfur-Containing Hydrocarbon Mixtures. M. M. Holm, L. F. Brooks, and B. E. Berlenbach to California Research Corporation.

In the extraction of S-containing hydrocarbon oils with HF to remove the S-compounds, the formation of free S during the extraction is prevented by substantially removing dissolved oxygen from the oil prior to the HF-extraction, e.g. by means of a stripping medium.

HEAVY OILS AND WAXES

U.S.P. 2,479,424. Rust Inhibiting Lubricants. L. W. Sproule and L. F. King to Standard Oil Development Company.

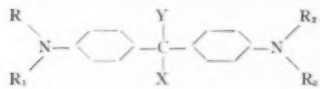
A mineral lubricating oil contains 0.5-5 percent by weight (based on the total composition) of sorbitan monostearate and 0.25-10 percent of sorbitan mono-oleate or pentaerythritol monooleate. The first named additive works as a rust inhibitor and the second as a solubilizer for the first.

U.S.P.2,479,513. Lubricating Oil. F. P. Richter and E. W. Fuller to Socony-Vacuum Oil Company, Inc.

Hydroxidibenzothiophenes or their alkyl substituents are employed to improve the stability of mineral lubricating oil.

U.S.P. 2,480,449. Mineral Oil Composition Containing Oxidation Inhibitor. R. Cocroft, E. W. Brennan, and A. Manteuffel to The Pure Oil Company.

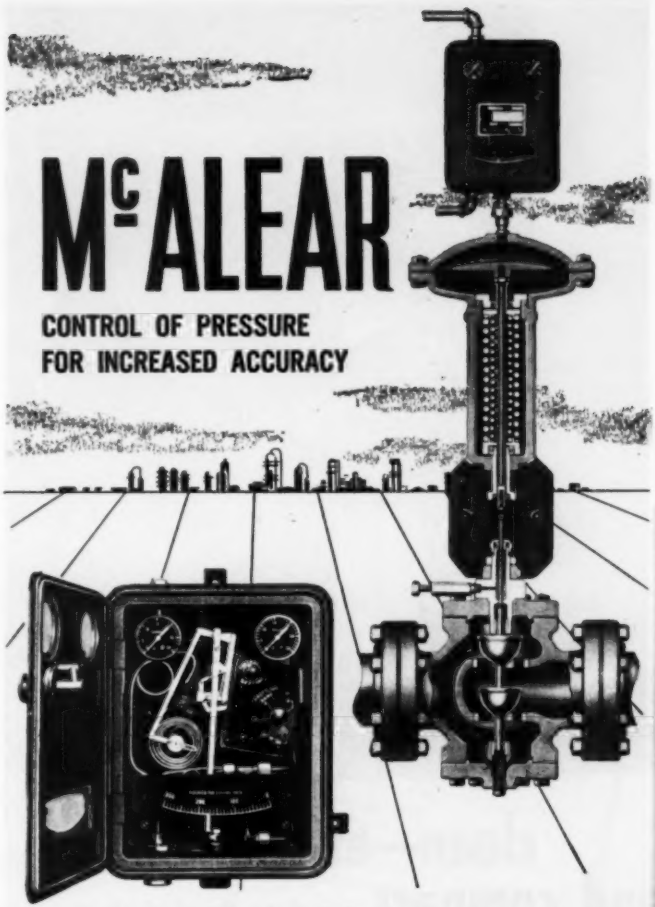
Hydrocarbon oil (e.g. lubricating oil) is protected against oxidation by a small addition of a compound of the formula



wherein R, R_1, R_2, and R_3 are either hydrogen or alkyl groups, X is hydrogen or a phenyl radical containing an amino or alkyl amino substituent in the para position to the central C atom of the molecule, and Y is a phenyl group containing a hydroxyl or alkoxy radical.

U.S.P. 2,480,450. Inhibiting Oxidation. R. Cocroft, E. W. Brennan, and A. Manteuffel to The Pure Oil Company.

Oxidation of lubricating mineral oil



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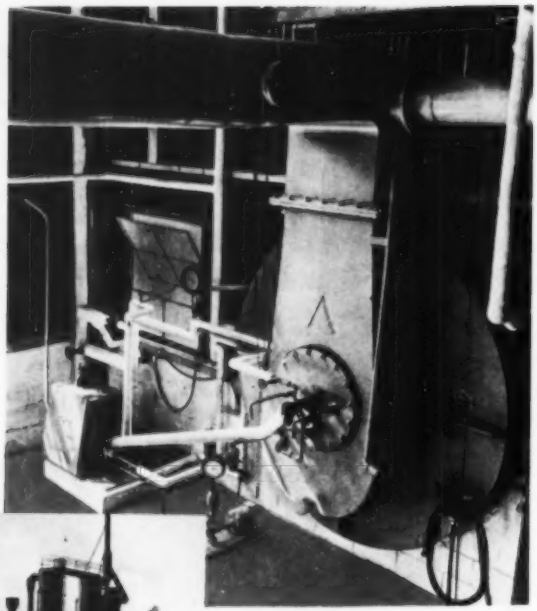

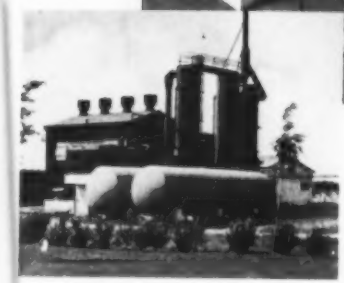

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Patents

is inhibited by a compound of a constitution similar to that of the additive according to U.S.P. 2,480,449. The main difference is that the Y group of the formula is a heterocyclic ring attached to the central C atom of the molecule by a C-C linkage.

U.S.P. 2,480,647. Method of Manufacturing Lubricating Grease. G. W. Gurd and L. W. Sproule to Standard Oil Development Company.

Aluminum soap is heated with mineral lubricating oil at a grease-forming temperature. The resulting grease is rapidly cooled by means of an external cooling medium to a temperature approximating its transition temperature. Solid CO_2 is then mixed into the grease to lower the grease temperature rapidly below the transition temperature. Mechanical breaking-down of the grease upon prolonged mechanical working during the transition from rubbery structure to gel structure is thus avoided.

U.S.P. 2,480,660. Lubricants. S. J. Lukasiewicz and A. N. Sachanen to Socony-Vacuum Oil Company, Inc.

Mineral lubricating oil contains an oxidation inhibiting amount of a sulfur-containing reaction product obtained in a manner claimed in detail from an animal or a vegetable oil and a certain sulfur-containing by-product tar.

U.S.P. 2,480,664. Lubricating Oil Composition. J. G. McNab, G. M. McNulty, and T. Cross, Jr., to Standard Oil Development Company.

Mineral lubricating oil contains dissolved therein 1 percent of a mixed alkaline earth metal salt of an alkylated phenol sulfide having an alkyl side chain of 4-8 C atoms attached to each benzene nucleus. The metal content of the salt shall consist of 15-85 percent of Ca and 85-15 percent of Ba or Sr.

U.S.P. 2,480,666. Transparent Metal Fabricating Lubricant. A. J. Morway and H. L. Leland to Standard Oil Development Company.

A light colored mineral lubricating oil contains 1-25 percent (based on the total composition) of a concentrate obtained by combining 10 percent light mineral oil with 5-20 parts of sulfur, 40-85 parts of a C_7-C_8 alkyl ester of abietic acid, and 2-15 parts of a metal sulfonate, heated to a temperature of 300-400° F. The light colored product is particularly effective as a cutting oil.

U.S.P. 2,480,673. Mineral Oil Lubricants. O. M. Reiff and H. J. Andress, Jr., to Socony-Vacuum Oil Company, Inc.

A mineral oil concentrate contains a dithiophosphoric acid of an alkyl-substituted phenol. The patent comprises a particular process for the production of this additive and its incorporation into an inert mineral oil.

U.S.P. 2,480,873. Lubricants. J. M. Musselman to The Standard Oil Company of Ohio.

Lubricating oil is compounded with 0.01-25 percent of the product obtained by reacting an oil-soluble fatty acid or fatty acid ester with a phosphorus sulfide in certain proportions and at a temperature of 175-450° F., and with

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are easily adaptable to changes in duty

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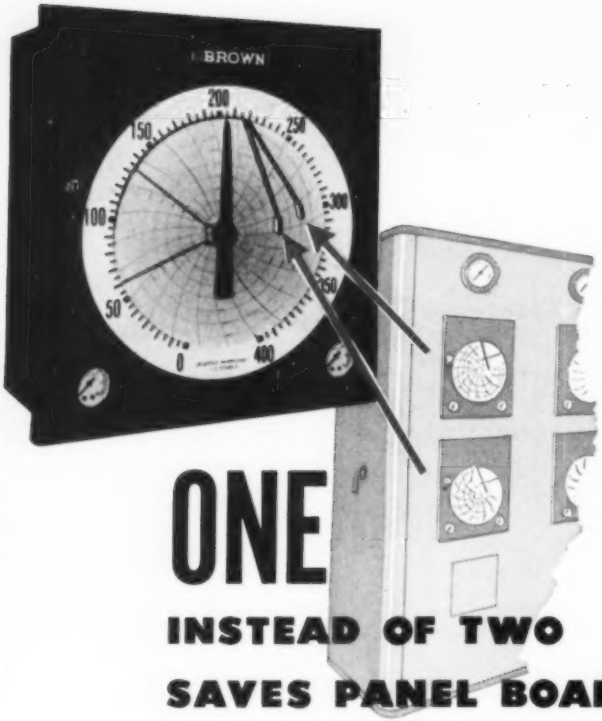

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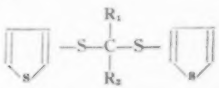
0.01-25 percent of an organic sulfonate or sulfate. Deterioration of the lubricant, particularly by sludge and acid formation and deposition of lacquer, varnish, etc., on the parts to be lubricated, are prevented by the additives.

U.S.P. 2,480,831. Thienyl Mercaptals and Mercaptols in Lubricating Compositions. J. W. Brooks to Socony-Vacuum Oil Company, Inc.

An amount of less than 10 percent by weight of a compound of the general formula,



wherein R_1 and R_2 are alkyl, aryl, aralkyl, or heterocyclic groups, is added to a mineral oil to stabilize it against oxidation. Thienyl mercaptals and mercaptols are the preferred additives.

U.S.P. 2,480,832. 3-Thienyl Thioethers in Lubricating Compositions. J. W. Brooks and S. J. Lukasiewicz to Socony-Vacuum Oil Company, Inc.

An amount of less than 10 percent by weight of an alkyl-, aryl-, alicyclic-, or aralkyl-3-thienyl thioether is added to mineral oil to stabilize it against oxidation.

U.S.P. 2,481,257. Lubricating Composition. M. W. Swaney and G. E. Sernink to Standard Oil Development Company.

Mineral lubricating oil is compounded with 0.05-10 percent by weight of an oil-soluble condensation product obtained from a certain rubbery hydrocarbon polymer and certain primary aliphatic mercaptans. Lubricants with improved viscosity characteristics are obtained.

U.S.P. 2,481,268. Crankcase Conditioning Oil. C. N. Watson to Standard Oil Development Company.

A mineral base lubricating oil suitable for lubricating the crankcase of internal combustion engines contains about 20 percent of a specified composition containing, among other ingredients, sodium petroleum sulfonate, sodium naphthenate, aromatic solvent naphtha, and diethylene glycol. The lubricant has cleansing properties.

PETROCHEMICALS

U.S.P. 2,478,914. Production of Benzothiophenes. B. S. Greensfelder and R. J. Moore to Shell Development Company.

A styrene hydrocarbon having a hydrogen atom attached to the nucleus in the ortho position with respect to the olefinic side chain is contacted in admixture with a molar excess of H_2S with a dehydrogenation catalyst at a temperature of 400-750° C. The catalyst preferably consists of an element of the first transition series of the periodic system in combination with an adsorptive carrier. Benzothiophenes are produced.

U.S.P. 2,479,082. Olefin Reactions. J. R.

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Patents

Roland and J. Harmon to E. I. du Pont de Nemours & Company.

Ethylene is reacted with a carboxylic acid anhydride having at least one hydrogen atom on a carbon alpha to the carboxylic anhydride group under increased pressure at a temperature of 100-400° C. in the presence of a positive halogen compound which yields alkali hypohalite when treated with an alkali hydroxide, such as an alkali metal N-haloaryl sulfonamide. Long chain fatty acid anhydrides are obtained.

U.S.P. 2,479,202. Recovery of Sulfonic Compounds from Sulfuric Acid Sludge. D. W. Bransky and N. E. Lemmon to Standard Oil Company of Indiana.

Unhydrolized sulfuric acid sludge resulting from the treatment of a hydrocarbon oil with strong H_2SO_4 is extracted with a paraffinic solvent. After removal of the extract, the remaining sludge is extracted with an aromatic hydrocarbon solvent in the absence of added water. Intermediate water-soluble, detergent-type sulfonic acids are thus obtained.

U.S.P. 2,479,306. Copolymers of Styrene with Furan or Monoalkyl Furan. T. L. Cairns, A. W. Larchar, and B. C. McKusick to E. I. du Pont de Nemours & Company.

A mixture of styrene and furan or a monoalkyl furan with 1-4 C atoms in the alkyl group is heated under a pressure of at least 4000 atm. and at a temperature of at least 125° C. but below the decomposition temperature of the reactants. High melting copolymers are obtained.

U.S.P. 2,479,450. Chemical Process for Tripolymers. D. W. Young and W. J. Sparks to Standard Oil Development Company.

A solid, plastic, non-hydrocarbon interpolymer is formed from 45-94 percent isobutylene, 1-5 percent multi-olefin with 4-10 C atoms and 3-50 percent of a chlorinated styrene with 1-2 Cl atoms in the ring, at temperatures of —40° to —164° C. in the presence of a metal halide Friedel-Crafts catalyst dissolved in a low-freezing non-complex-forming solvent liquid at the reaction temperature, such as $AlCl_3$ in methyl or ethyl chloride.

U.S.P. 2,479,490. Synthetic Rubbery Reaction Products of Butadiene Hydrocarbons and Saturated Aliphatic Compounds. H. M. Guinot and R. Buret to Les Usines de Melle (Soc. Anon.).

A butadiene hydrocarbon is reacted in the heat with 10-40 percent of a saturated compound of the formula $R—CH_2—R'$ wherein R and R' are CN, COO—alkyl, or $COCH_3$ in an aqueous medium containing an emulsifier and a peroxide catalyst. Rubber-like copolymers are produced.

U.S.P. 2,479,879. Production of Nitriles and Amines from Ammonia and Olefins. J. W. Teter to Sinclair Refining Company.

Nitriles and amines are produced by directly contacting a mixture of an olefin and an excess of ammonia at a temperature of 400-700° F. and a pressure of about 1500 psi. with a catalyst

consisting of reduced metal oxide and including an oxide of cobalt or nickel deposited on an inert carrier and containing more than 1 percent sodium.

U.S.P. 2,479,996. Synthesis of Organic Sulfur Compounds. R. T. Bell and C. M. Thacker to The Pure Oil Company.

Mercaptans and alkyl sulfides are prepared by contacting an olefin with H_2S in the presence of BF_3 and HF. Temperatures between —35° and 200° C. are preferably employed.

U.S.P. 2,480,021. Production of Vinyl Halides. J. C. Hillyer to Phillips Petroleum Company.

A mixture of acetylene, HF, and HCl is contacted with a $HgCl_2$-catalyst at a temperature of 200-650° F. A mixture of vinyl flouride and vinyl chloride is obtained. The yield of vinyl fluoride is greatly increased compared with that obtained when HF only is reacted with acetylene in the presence of $HgCl_2$.

U.S.P. 2,480,266. Manufacture of Organic Amines. L. Schmerling to Universal Oil Products Company.

A tert. monohalo-saturated hydrocarbon is reacted with an aliphatic non-tert. Mono-olefinic hydrocarbon in the presence of a Friedel-Crafts catalyst consisting of a chloride or a bromide of Al, Fe, Bi, Zr, or Zn. The higher molecular weight monohalo-saturated hydrocarbons formed which contains a quatern. C atom removed for at least one C atom from that attached to the halogen is reacted with ammonia or an organic amine. The resultant product is treated with alkali. A saturated organic amine containing a quatern. C atom is obtained.

U.S.P. 2,480,465. Thiophene Sulfonic Acid Preparation. H. S. Halbedel and J. C. Heath to The Harshaw Chemical Company.

Thiophene is contacted with fluosulfonic acid. The resulting mixture of thiophene sulfonyl fluoride and thiophene sulfonic acid is contacted in aqueous solution with an alkaline earth hydroxide to convert both compounds to a thiophene sulfonic acid alkaline earth salt and to precipitate alkaline earth fluoride.

U.S.P. 2,480,939. Xylene-Benzene Conversion. R. J. Lee and H. D. Radford to Pan American Refining Corporation.

A mixture of a xylene and benzene containing 35-45 mol. percent xylene is contacted with at least 200 percent by weight of a HF catalyst at a temperature of 300-450° F. under sufficient pressure to maintain liquid phase and produce toluene.

U.S.P. 2,480,940. Production of Aliphatic Ethers. L. N. Leum, S. J. Macuga, and S. I. Kreps to The Atlantic Refining Company.

Isobutylene and a primary or secondary saturated aliphatic alcohol with 1-12 C atoms are contacted with an organic hydrogen ion exchange catalyst in which the functional group is SO_3H, OH, or COOH at a temperature of 210-250° F. under a pressure of 50-500 psi. An alkyl tert.-butyl ether is formed.

U.S.P. 2,480,971. Sensitization of Hydro-

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In many cases it is possible to effect considerable saving in costs through the selection of the proper gasoline antioxidant. Various gasolines will have different antioxidant responses. Similarly, different quality requirements may demand considerable difference in antioxidant characteristics. To meet these variable demands and to provide you with the most economical method of controlling oxidation, Du Pont offers 3 gasoline antioxidants—No's. 5, 6, and 22—from which the most effective can be selected.

As shown in the charts on the opposite page, Antioxidant No. 22 proved most effective in Stock A, Antioxidant No. 5 in Stock B. With gasoline C, in meeting this refiner's combined specifications of 240 minute induction period and 10 mg. copper dish gum, Antioxidant No. 6 proved most economical, although No. 5 gave the best induction period response. Wherever copper dish gum is of importance, Antioxidant No. 6 is usually the most economical. An added feature of Antioxidant No. 22 is its very low water solubility. Where water extraction by tank bottoms or in pipe lines, or extraction by caustic washing is a problem, Antioxidant No. 22 may be the answer. Whatever the Antioxidant treating problem—for maximum economy and maximum effectiveness—choose one of these 3 Du Pont Gasoline Antioxidants.

For complete information, or for samples, ask your Du Pont representative or contact your nearest District Office.

DU PONT ANTIOXIDANT NO. 5—is a solution containing 50% Normal-butyl-para-aminophenol, 30% Anhydrous isopropanol, and 20% Anhydrous methanol.

DU PONT ANTIOXIDANT NO. 6—is a solution containing 50% Iso-butyl-para-aminophenol, 30% Anhydrous iso-propanol, and 20% Anhydrous methanol.

DU PONT ANTIOXIDANT NO. 22—is a commercial grade of N,N' disecondary butyl-para-phenylene-diamine containing no solvents.

Concentration of Antioxidant* required to meet refiner's specification indicated below.

Gasoline C See Curve At Right	*240" Induction Period*	*10 mg. Copper Dish Gum*	*Combined Ind. Per. and Copper Dish Gum*
Antioxidant No. 5	0.0012%	0.0021%	0.0021%
Antioxidant No. 6	0.0014%	0.0009%	0.0014%
Antioxidant No. 22	0.0018%	0.0027%	0.0027%

**Active ingredient basis*

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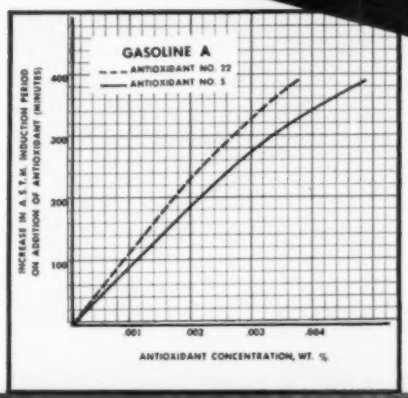

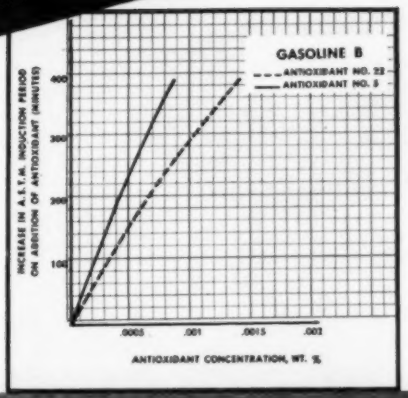

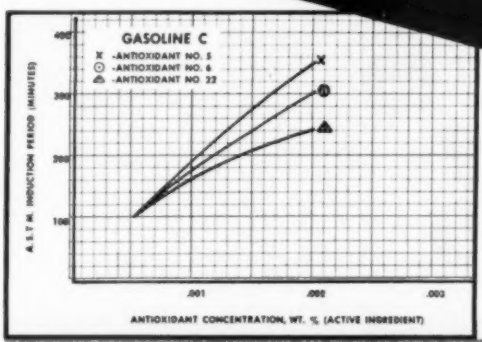

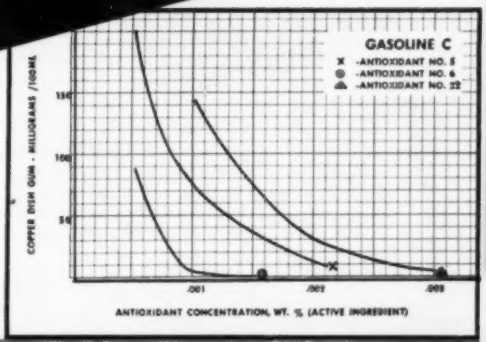

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If you just want an extra good valve for general service, then choose the "Renewo" with Regular Type Nickel Alloy Seat and Disc. It's tops in its class.

Or, perhaps you have a throttling condition such as drain, drip, water column blow-down and like service where regular seats and discs tend to cut out . . . use the "P" (Plug Type) "Renewo" with 330 Brinell "NS 5" Alloy Seat and Disc. Here you have high resistance to wear and corrosion.

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1. REGULAR TYPE *"Renewo"* Nickel Alloy Seat and Disc for general service.

2. "P" (PLUGTYPE) *"Renewo"* "NS5" Nickel Alloy 330 Brinell Seat and Disc for throttling, drain, drip, water column blow-down and like service.

3. "PS" (PLUG TYPE) *"Renewo"* Stainless Steel 500 Brinell Seat and Disc for close throttling and other severe erosive service.

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Patents

gen Bromide Catalyzed Oxidation Reactions. F. F. Rust and W. E. Vaughan to Shell Development Company.

Aliphatic and aromatic hydrocarbons are subjected to controlled oxidation by the action of oxygen in the presence of HBr at a temperature of 100-225° C. and of 0.1-10 percent of a monochloride of 3 C atom acyclic hydrocarbon, such as isopropyl chloride. The yield of desired oxygenated products is greatly increased by the addition of this sensitizer while the concentration of HBr can be reduced.

U.S.P. 2,481,160. Production of Halocycloalkanes. L. Schmerling to Universal Oil Products Company.

A monohalocycloalkane is reacted in the presence of a Friedel-Crafts halide catalyst with a mono-olefin. Higher boiling halocycloalkanes are obtained.

Process Issue Corrections

In the September, 1949, Process Issue of PETROLEUM REFINER, on page 126 there appeared a notation to the effect that "The Dowtherm vapor heating process has been applied to a number of distillation units designs by Foster Wheeler Corporation, New York. For several years The Dow Chemical Company and Foster Wheeler Corporation have cooperated in the application of Dowtherm to industrial process heating. Foster Wheeler holds exclusive rights for building all Dowtherm boilers having capacities of 1,000,000 Btu./hr. or over."

It has been called to our attention that this last statement above is in error. A letter from The Dow Chemical Company, Midland, Michigan, advises that "While at one time we did have such an agreement with Foster Wheeler, this agreement has long since expired and at the present time there is no agreement, restrictive or otherwise between The Dow Chemical Company and a manufacturer of any type of equipment extending to such manufacturer any protection under any patents of The Dow Chemical Company covering the use of Dowtherm or any other heat transfer fluid. In addition to Foster Wheeler Corporation, the following companies have made and are in a position to offer Dowtherm equipment that has proved suitable: Eclipse Fuel Engineering Company of Rockford, Ill.; Wicks Boiler Company, Saginaw, Mich.; Union Iron Works, Erie, Pa.; Struthers Wells Corporation, Warren, Pa."

Further, in the index of processes for the September issue were two omissions that are sincerely regretted. The Tretolite Company, St. Louis 19, should have been included in the list of "Owners, Manufacturers, and Licensors of Processes," because of their connection with the Chemical Desalting Process, page 265, as a long time manufacturer of treating chemicals and consultant on refinery treating problems. The Thermofor Clay Revivification Process, page 295 of the September issue, should have been credited on this same list as a process of Max B. Miller, Inc., 501 Fifth Avenue, New York.

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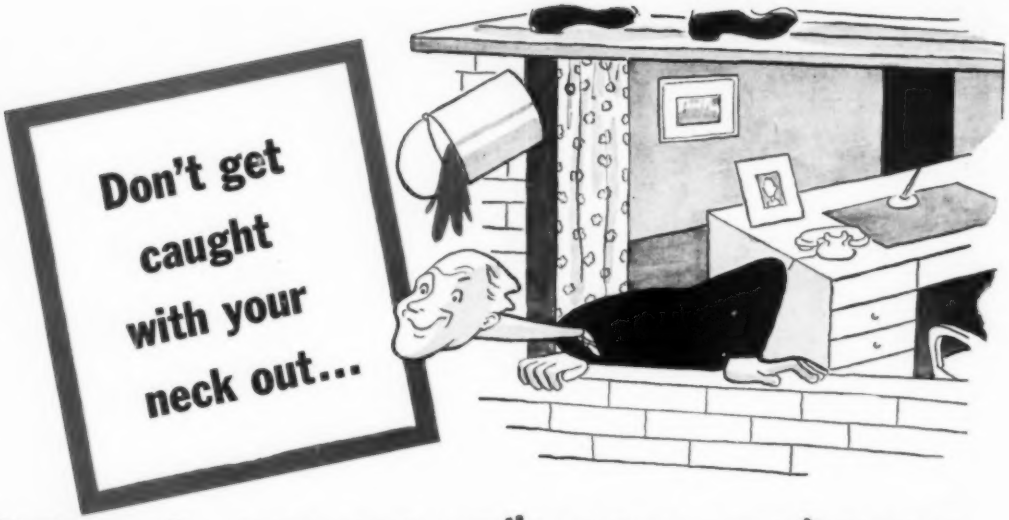
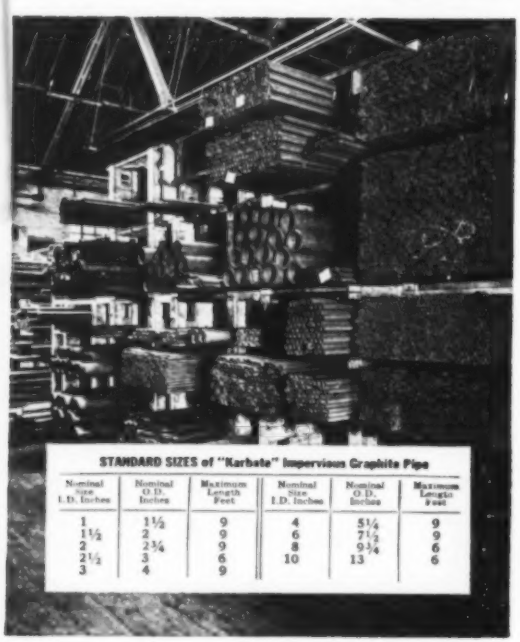


KEEP A STOCK OF "KARBATE" PIPE TO HANDLE ANY EMERGENCY!



STANDARD SIZES of "Karbate" Impervious Graphite Pipe

Nominal Size I.D. Inches	Nominal O.D. Inches	Maximum Length Feet	Nominal Size I.D. Inches	Nominal O.D. Inches	Maximum Length Feet
1	1½	9	4	5¼	9
1½	2	9	6	7½	9
2	2¾	9	8	9¾	6
2½	3	6	10	13	6
3	4	9			

KEEP a full stock of corrosion-resistant "Karbate" Impervious Graphite Pipe in an adequate range of sizes and you will never be caught short by an emergency replacement job . . . or have to waste time ordering whenever there is a routine repair to be made. "Karbate" pipe, valves, fittings, towers, pumps, tanks and other equipment offer you many advantages:

- **Both acid-resistant and alkali-resistant**
- **Light in weight, easy to machine and assemble**
- **Immune to thermal shock**
- **No metallic contamination of product**

Write for new Installation Manual, Catalog Section M-8801A, Address Dept. PR

The term "Karbate" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide UCC *and Carbon Corporation*

30 East 42nd Street, New York 17, N. Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

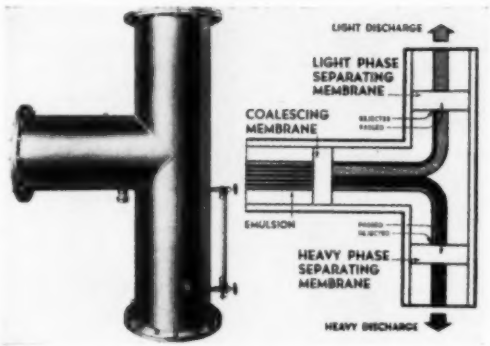
Foreign Department: New York, U.S.A.

These products sold in Canada by Canadian National Carbon Co., Ltd., Toronto 4, Canada

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information about products described on these pages write to the address shown, using the number shown for each item desired.

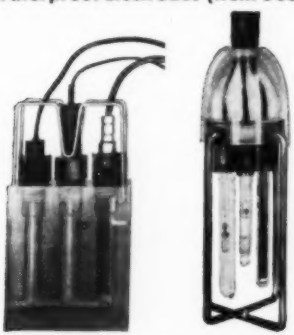
Liquid Separator (Item 584)



"Complete phase separation and recovery of liquids, including stubborn emulsions," is accomplished at production rates by the new liquid separator," developed and produced by Selas Corporation of America. The separator employs the physical principle of successive membranes, in which the first of the series has the function of coalescence and the second has the function of final separation. The controlled performance membranes permit rapid flow rates through the unit, from 500 to 1500 gallons per hour, with relatively low pressure-drops. The shells of the separators are constructed of carbon or stainless steel. Emulsions usually encountered in chemical and pharmaceutical processes, such as steam distillations, solvent extractions, and organic reactions, can be separated by these units. Emulsions that are chemically stabilized by surface-active agents cannot be separated. Solid contaminations, particularly of gelatinous nature, may cause abnormal pressure drops across the coalescing membranes.

For further information write Selas Corporation of America, Erie Avenue and D Street, Philadelphia 34, referring by number to this PETROLEUM REFINER item.

Waterproof Electrodes (Item 585)



Two pH electrode assemblies developed by Leeds & Northrup Company for use with recorders and controllers feature waterproof design. One assembly is for continuous sampling lines, the other for immersion in open channels and tanks. The sampling line assembly has low capacity which permits a high flow rate and minimizes the coating of electrodes by suspended material. Operating pressure up to 15 pounds can be produced. Body of the assembly is a single block of clear plastic, 4¼ x 1⅜ x 4¾ inches. Inlet and outlet connections fit standard ¼ inch pipe. The immersion unit can be used at a depth of ten feet, or greater with longer lead wires.

For further information write Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, referring by number to this PETROLEUM REFINER item.

Plastic Coatings (Item 586)

Rubber-like plastic materials, which are said to possess many chemical properties lacking in both natural and synthetic rubbers, have been developed by United Chromium, Incorporated. These materials, known as unichrome plastisol and organosol compounds, include advantages such as "resistance to a wide variety of chemicals and corrosives, resistance to mechanical abuse such as abrasion, high dielectric strength, and easy handling. Unichrome plastisols and organosols are delivered in paste-like form. The plastisols contain 100 percent solids, and the organosols, a small percentage of liquid solvent or diluent. They can be molded or they can be applied as coatings to metal, fabric, or paper by dipping, spraying, or brushing. Coatings from .003 to .25 inch may be obtained with a single application.

For further information write United Chromium, Incorporated, 51 East 42nd Street, New York 17, referring by number to this PETROLEUM REFINER item.

Platform Ladder (Item 587)

An extension aluminum aerial platform ladder, manufactured by Aero Metalcraft Corporation, is designed for mounting on "most materials handling" trucks or other truck bodies, and can also be used when truck is in motion. It is claimed to be 100 pounds lighter than other all-aluminum ladders of its type. The ladder extends to a height of 28 feet and rotates 360 degrees. Models for exterior applications are available in lengths up to 60 feet. Manual or hydraulic actuation controls the inclination of the ladder to 14 feet laterally from the center of the truck.

For further information write Aero Metalcraft Corporation, Rockleigh, N. J., referring by number to this PETROLEUM REFINER item.

Roofing Fabrication (Item 588)

A new off-the-job, tailor-made roofing and siding fabricating service, adapted for those process plant buildings usually sheathed with corrugated metal or asbestos, has been announced by Childers Manufacturing Company in an engineering bulletin. The company claims they can ship to job sites in the Mid-West, Mid-South, or Southwest at considerable savings to the roofing contractors. The roofing and siding supplied by this service is Alcoa's newly developed industrial roofing sheet of deeply corrugated .032" aluminum, previously available only in warehouse stock sizes. Childers now has made the material cut to exact lengths and on the

diagonal as necessary. This roofing is said to allow purlin spacing and loading comparable with corrugated asbestos or protected metal. It is 2½ inch corrugated, with corrugations ⅞ inch deep. This results, in a calculated allowable uniform load (safety factor of two) of 80 pounds per sq. ft. with a four-foot purlin spacing.

For a copy of the bulletin write Childers Manufacturing Company, 625 Yale Street, Houston, referring by number to this PETROLEUM REFINER item.

Rubber Pinch Valve (Item 589)

Non-corrosive and non-clogging, Ray Wilcox Company's rubber pinch valve is recommended for use in pipe lines handling acids and salt solutions, lime slurry, sand, coal and other abrasive and corrosive slurries and liquids difficult to handle or injurious to metal valves. The valve is comprised of three essential parts: rubber tube, pinching mechanism and housing. The straight round tube with integral flanges is built of natural rubber reinforced with woven duck plies. A steel yoke with two half round steel members that are brought to a closing position by a screw arrangement comprise the operating or pinching mechanism. All operating parts, including the non-rising bronze screw, are outside of the rubber tube and are contained in a sealed cast aluminum alloy housing. The valve's position can be changed by removing flange bolts and

rotating the tube part of a turn to assure even wear on all sides.

For further information write Ray Wilcox Company, 1436-37 Land Title Building, Philadelphia 10, referring by number to this PETROLEUM REFINER item.

Tool Crib Control (Item 590)

"How Tool Costs Were Cut 12 Ways in 20 Plants," with tool crib control, is the title of The McCaskey Register Company's booklet which is based on written reports of savings from representative plants, condensed for faster reading.

For a copy write The McCaskey Register Company, 101 West 31 Street, New York, referring by number to this PETROLEUM REFINER item.

Fire Unit (Item 591)

A fire fighter mobile unit which discharges a foam blanket for control of gasoline and oil fires has been manufactured by Walter Motor Truck Company. The unit, which weighs 21 tons, carries 1000 gallons of water, 90 gallons of foam liquid for mixing and 800 pounds of carbon dioxide. The 240-hp. motor accelerates to 45 miles per hour in less than one minute. The two 140-hp. motor and centrifugal pump units discharge 600 gallons per minute at 300 psi. A resulting blanket is discharged to two turret nozzles of 200 gpm. each, together with ground sweep nozzles and three foam hand lines.

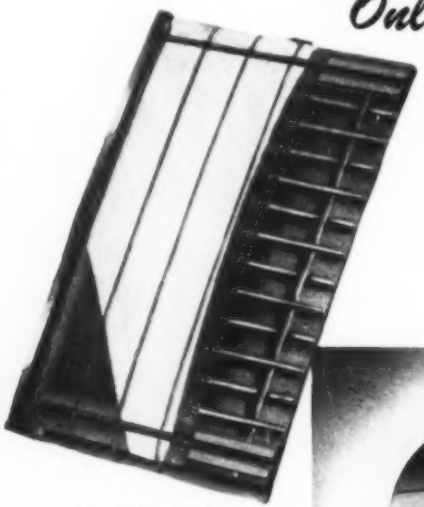
For further information write Walter Motor Truck Company, 1001-19 Irving Avenue, Ridgewood, Queens, Long Island, N. Y., referring by number to this PETROLEUM REFINER item.

Rotational Viscometer (Item 592)

Precision Scientific Company has redesigned the interchemical rotational viscometer and placed all operating parts within one housing. The viscometer has a broad utility and will give complete data on the flow properties of greases, paints, plastics, adhesives, etc. It produces consistency curves in place of single point measurements which are usually misleading for plastic, thixotropic materials and consists essentially of a rotating sample cup and a stationary bob immersed in it. The speed of cup rotation can be varied from 10 to 400 rpm. in steps of 10 rpm. with General Electric Company's thy-mo-trol drive.

For further information write Pre-

Only GB FILTERS have "It"

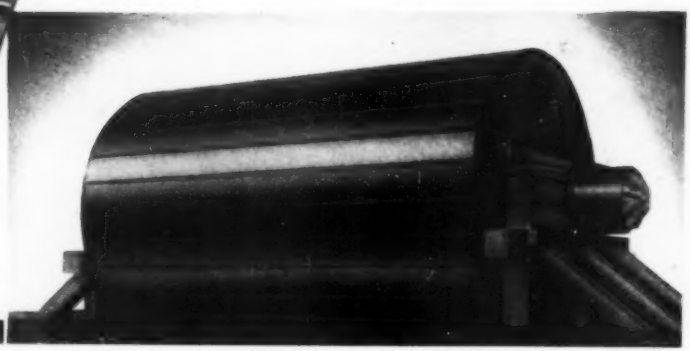


"It" is the G-B patented drum compartment drainage shown in the close-up at left. From the rugged, precision machined division bars to the die-formed wire and locking strips, G-B drainage was designed to provide

1. **Smooth, uniform support for maximum cloth life**
2. **Easy cloth replacement and drainage screen renewal**

These features help you obtain

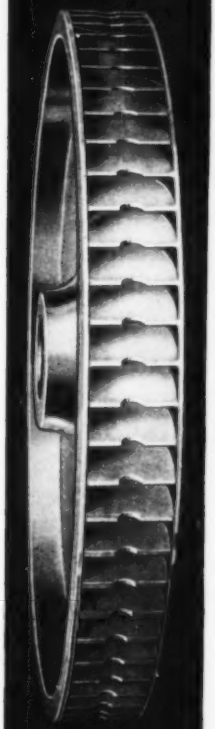
LOW MAINTENANCE COST
GREATER TIME ON STREAM

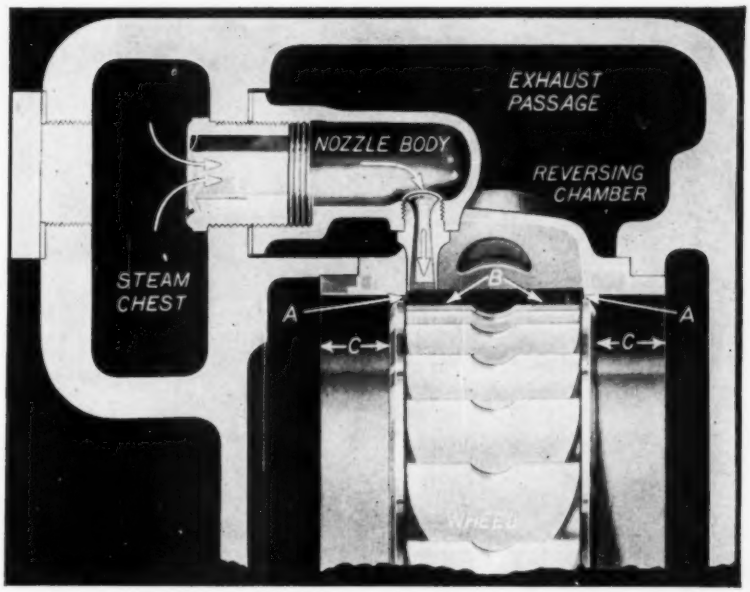


For complete details on G-B Filters, write

GOSLIN-BIRMINGHAM
MANUFACTURING COMPANY, Inc.
Birmingham, Alabama
350 Madison Ave., New York

TERRY





AMPLE CLEARANCES FOR DEPENDABILITY

Large blade and rim clearances and extra large side clearance — one inch — help make Terry One-piece Wheel Turbines highly dependable in operation.

The blades cannot foul because of the protection afforded by the rims, which are not damaged, should rubbing occur.

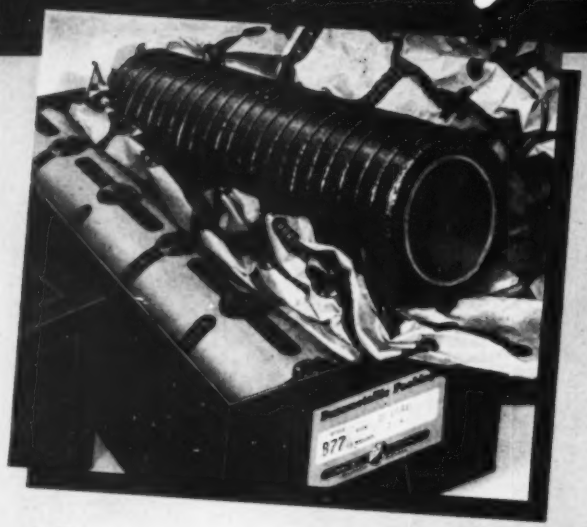
Note the rim clearance, AA in diagram. Also the large blade clearance, B. Side clearance, CC, is so large that end-play from external thrust cannot damage wheel.

Terry Bulletin S-116 will give you full information on the Terry Wheel Turbine. A request on your business letterhead will bring you a copy.

T-1171

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

DURA PLASTIC *Packings*



USERS everywhere are testifying to the outstanding service performed by this general purpose semi-metallic packing. DURA PLASTIC provides improved sealing for gasoline — water — air — steam — oils and chemicals . . .

- ★ No "breaking" when formed around shafts
- ★ Remains uniform in shape under compression
- ★ Retains resiliency throughout life of its use
- ★ Lubricated metallic shreds reduce frictional wear

Write Today for Your Copy Of File No. DPPR . . .
describing types and styles of metallic and semi-metallic packings to meet your specific need.

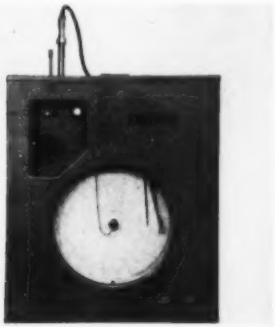
The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

MANUFACTURERS OF METALLIC and SEMI-METALLIC PACKINGS
ROTARY MECHANICAL SEALS and PACKING TOOLS

cision Scientific Company, 3737 W. Cortland Street, Chicago 47, referring by number to this PETROLEUM REFINER item.

Refractometer (Item 593)



The Dow Chemical Company and Precision Scientific Company have developed a production control instrument, the robomatic refractometer which "continuously and graphically records results 24 hours a day." The apparatus covers the range of refractive indices from 1.32539 to 1.54409. Control over this entire range to within three parts in the fifth decimal place is claimed. Specific applications include the production of plastics, synthetic rubber, petroleum products; the manufacture of ammonia, pharmaceuticals, bleaches, vinegars—all aqueous, solutions not having suspended solids; and pipe line distribution for pilot plant operations in industry or laboratory research.

For further information write Precision Scientific Company, 3737 W. Cortland Street, Chicago 47, referring by number to this PETROLEUM REFINER item.

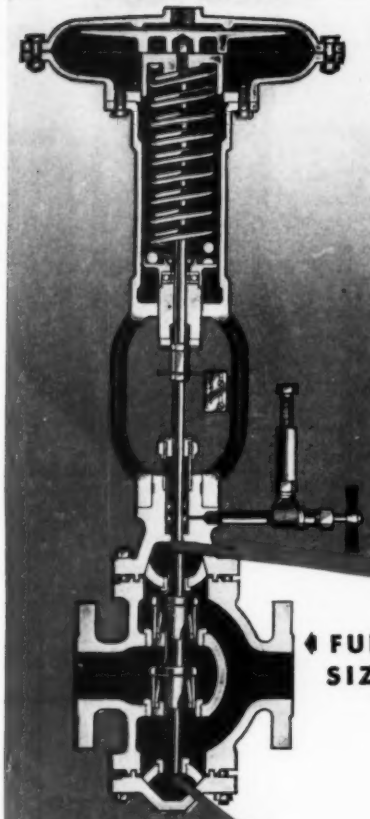
Handling Arms (Item 594)

"From one to four drums or barrels of material may be safely and efficiently handled at the same time without the need of pallets with the new four-drum handling arms" offered by Hyster Company for its load-grab attachment mounted on the "40" lift truck. Drums may be lifted in either horizontal or vertical position by means of hydraulic side pressure. When installed on the revolving load-grab, the drum-handling arms may be used to turn-over or dump drums or barrels. Rubber-faced gripping surfaces on the arms prevent scratching. Capacity of the drum-handling arms rated at 23 inch load centers is 2800 pounds with the regular load-grab and 2380 pounds with the revolving load-grab.

For further information write Hyster Company, 2902 N. E. Clackamas Street, Portland 8, Ore., referring by number to this PETROLEUM REFINER item.

Floating Skimmer (Item 595)

The new floating skimmer, manufactured by Boiler Specialties Corporation, and intended for use in boilers to achieve blowdown of suspended and dissolved solids from a point at or near the water



RESTRICTED INNER VALVE PROCEDURE FOR FISHER DIAPHRAGM CONTROL VALVES . . . . . .

The introduction of Fisher's new restricted inner valves offers a quick, economical and completely satisfactory way to reduce the effective capacity of a larger nominal valve size.

INTERCHANGEABLE

FULL SIZE

1 SIZE SMALLER

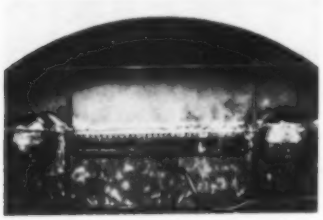
2 SIZES SMALLER

PRACTICAL

For example, a 4" valve can quickly be converted to flow capacity of a 3" 2½", or 2" size. This is accomplished by the restricted V-Port Inner Valve alone—without changing seat rings. Inner valves with equivalent smaller size valve area or capacity are fully interchangeable with standard full size inner valves. Inner valve skirts are cast stainless steel with wide range percentage characteristics port areas. Cast skirts are welded on to stainless steel bar stock center post guide. Further details and application data gladly furnished on request.

FISHER GOVERNOR COMPANY MARSHALLTOWN, IOWA

New Equipment



surface, is made of stainless steel and consists of a shallow adjustable trough suspended between two spherical floats, and having a screen mounted over the trough. It is designed to provide automatic continuous blowdown at a predetermined point near the water surface, "regardless of fluctuation in the water level."

For further information write Boiler Specialties Corporation, 608 S. Dearborn Street, Chicago, referring by number to this PETROLEUM REFINER item.

Ladders (Item 596)

"Alcoa-Lite Aluminum Ladders for Industry," is an Aluminum Ladder Company folder which describes folding step ladders, warehouse ladders, and straight ladders and gives weights of the ladders in the tables of specifications.

The company's products will now be sold under the trade name of "Alcoa-Lite" to distinguish them from like products which are made of aluminum.

For further information write Aluminum Ladder Company, Worthington, Pa., referring by number to this PETROLEUM REFINER item.

Thread Sealer (Item 597)

Designed to be easily carried in either pocket or tool kit, a new thread sealing compound called "Thread-Tite" has been developed by Armite Laboratories. Application of this stick to any pipe threads before joints are made up "provides a positive seal against gases, brine, acids, water, steam and ammonia at high and low-pressures and temperatures."

For further information write Armite Laboratories, 6609 Broad Street, Los Angeles 1, referring by number to this PETROLEUM REFINER item.

Shaft Seal (Item 598)

Peerless Pump Division of Food Machinery and Chemical Corporation has developed a new mechanical shaft seal for prevention of leaks around a rotating shaft. Described in Bulletin B-571, these seals are available in standard, abrasive-resistant and special classifications. The maximum pressure recommended for these seals is 400 psi. Liquid temperature up to 250° F. without water cooling, and liquid temperatures up to 300° F., with water cooled stuffing boxes can be handled.

For a copy write Peerless Pump Division, Food Machinery and Chemical Corporation, 301 West Avenue 26, Los Angeles 31, referring by number to this PETROLEUM REFINER item.

Chemograph (Item 599)

Designed for rapid, accurate polarographic analyses, a new Type E electrochemograph, offered by Leeds & Northrup Company, features a one-piece console design incorporating a built-in speedomax recorder. The instrument plots diffusion current as a function of voltage and data is taken by a speedomax microampere recorder. Controls are centralized on one panel. Other features include four degrees of damping; eleven current ranges to cover full-scale readings of 1, 2, 3, 5, 7, 10, 15, 20, 30, 50

"The Best Prophet of The Future IS THE PAST"

And The Long and Successful Record of Insul-Mastic Coatings Foretells The End of Corrosion for Your Plant

Insul-Mastic can prevent corrosion in your Plant

Your problem may be unique, but Insul-Mastic's record proves that this destruction CAN be prevented. You will find it profitable to be guided by the age-old proverb, "THE BEST PROPHET OF THE FUTURE IS THE PAST."

Before you use *Insul-Mastic* Coatings you know that your *future* Maintenance costs are going to sink right out of sight. The performance record of Insul-Mastic predicts this unerringly for you.

(1) *Insul-Mastic* alone met the original U.S.Government specifications for the preservation of war materiel.

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(3) *Insul-Mastic* stopped acid and alkali corrosion in great industrial plants of our nation.

Our engineers are ready to help you. Bring your corrosion problems to us.

Insul-Mastic Corporation
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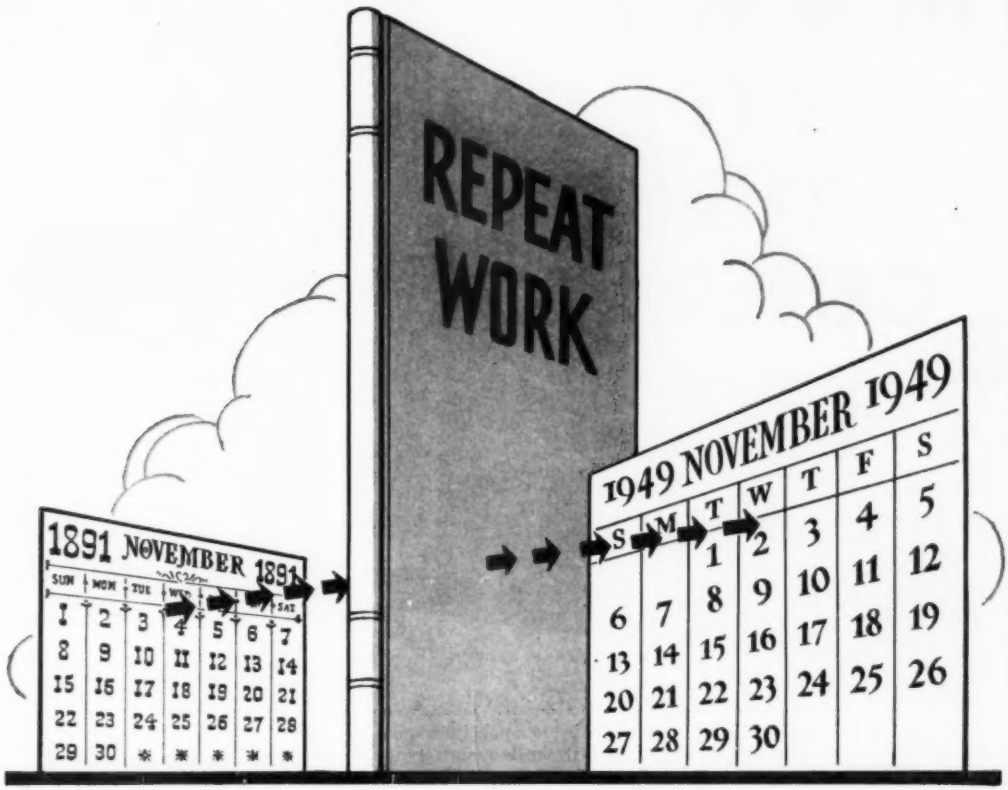
OLIVER BUILDING • PITTSBURGH 22, PENNSYLVANIA

INSUL-MASTIC COATINGS
• CORROSION PROOFING
• WATER PROOFING
• VAPOR SEALING
• INSULATION

A MEASURE OF SATISFACTION



80% of all the construction work we have completed since 1891 has been for clients previously served—a tangible measure of client satisfaction.

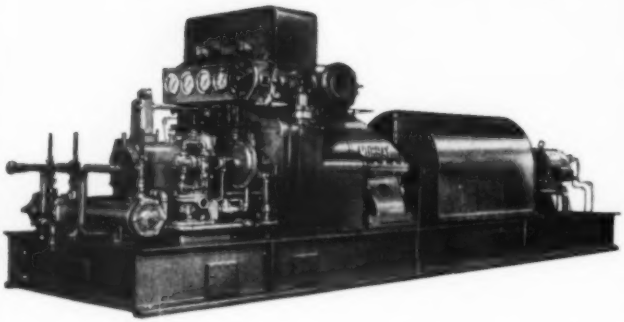
80%

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

MURRAY

TYPE D TURBO-GENERATOR



Murray Type D turbo-generators are built in a capacity range from 500-3000 KW. Turbines are either direct-connected to 2-pole generators or operate through reduction gears connected to 6-pole generators at 1200 RPM. Direct current and 25 cycle machines are also available. This type machine is regularly furnished in the above capacity range either condensing or non-condensing and may be of the automatic extraction type or for high back pressure. Units may be mounted either on soleplates or on a fabricated steel base.

This type turbo-generator is designed to operate on steam conditions up to 600#, 750° F. TT. Auxiliary equipment normally includes combined trip throttle valve, complete pressure lubrication system including oil tank, oil filter, coolers, and automatic turbine-driven auxiliary oil pump. Gauge board with gauges, vibrating reed tachometer and necessary thermometers are also furnished.

The above photograph shows a machine of this type rated at 1000 KW. Two duplicate machines are installed in our Nation's Capitol.

Murray turbo-generators have long been noted for their rugged construction, operating economy and long life with a minimum of maintenance.

WRITE TODAY FOR FULL DETAILS

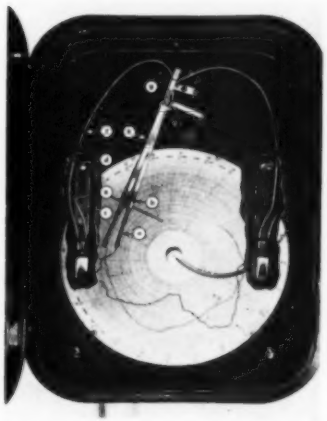
MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

BUILDERS OF STEAM POWER EQUIPMENT
FOR THREE QUARTERS OF A CENTURY

and 100 microamperes; and three polarizing voltage ranges of 0 to —2, —1 to —3 and +1 to —1 volts. Voltage can be adjusted to ±4 mv. by calibration against an integrally-mounted standard cell.

For further information write Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, referring by number to this PETROLEUM REFINER item.

Recording Pen (Item 600)

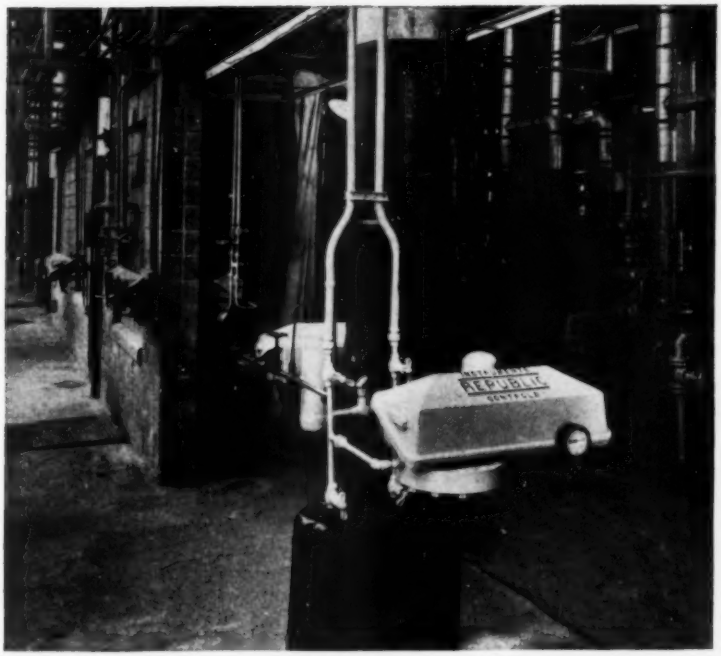


Chartomatic Company's pen, designed for use in recording instruments such as orifice meters, proportioning meters, rate of flow controllers, temperature recorders and pressure recorders, is claimed to "write for months without servicing or replenishing the ink supply that is closed to the atmosphere and dirt." Tubular pen points (a) are attached to pen arms with metal clips (b). The bottle may be filled with a fast-drying ink, clipped to the mounting brackets (c) and suspended from the chart plate supporting posts (d) or other screws in the case. Ink feed is governed by capillary action and the flow started by blowing through the vent tube (e). Plastic tubing (f) is hung freely on the pen shaft (g) and does not affect sensitivity of pen arm motion. It is clipped to pen arm by small wire loops (h). Ink travels from bottles through tubing to the tubular steel pen point.

For further information write Chartomatic Company, Department G, 2068 East 37th Street, Los Angeles 11, referring by number to this PETROLEUM REFINER item.

Switch Box (Item 601)

A new explosion proof switch box, designed to accommodate mercury tubes to make and break electrical circuits, manufactured by Shand & Jurs Company, is known as Figure ST-5500, and is listed by Underwriters Laboratories for use in hazardous (Class 1, Group D) locations, in ambient temperatures up to 155° F. Body and cover of the switch are of cast aluminum. The body is provided with mounting flanges, and measures approximately 9½ inches long by



These Meters Had To Be
ACCURATE — FLEXIBLE — RUGGED

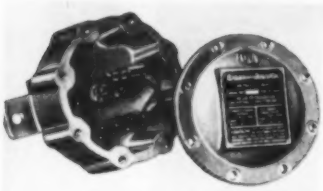
One hundred twenty one Republic Pneumatic Transmitters are measuring the flow and level of various acids in a large chemical processing plant, a section of which is pictured above.

These transmitters have a guaranteed accuracy of within ½ of 1% of the transmitter range. By making a few minor adjustments or substituting a few small parts, their operation can be easily changed to any desired range between a minimum of 0—0.6" of water to a maximum of 0—704" of water. Their construction is more like that of a precision machine than of the sensitive instrument they are. It is for these reasons that Republic Pneumatic Transmitters, even though comparatively new, have already been specified and installed on over 2500 industrial metering applications.

Republic Pnuematic Transmitters are available for measuring flow, liquid level, pressure or liquid density of a wide range of fluids. They employ the force-balance principle to convert these process variables into air pressures which vary proportionally. These air pressures become direct measurements and can be conducted to reading instruments or used as the measuring impulse for the actuation of an automatic controller.

Data Book No. 1001 contains complete details on the construction and operation of Republic Transmitters. Write for your copy today.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

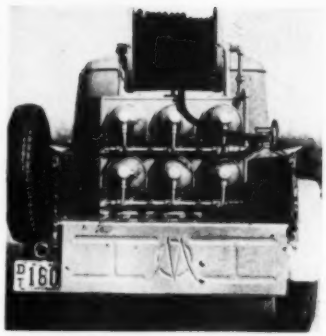


5¼ inches deep. It is provided with a threaded hub to accommodate a stainless steel operating shaft on which are mounted the two mercury tube electrodes. A ½ inch threaded outlet is also provided for conduit connection.

For further information write Shand & Jurs Company, Berkeley, Calif., referring by number to this PETROLEUM REFINER item.

Carbon Dioxide Cylinder (Item 602)

Walter Kidde & Company, Inc., has developed a compact carbon dioxide cylinder and hose reel unit that can be installed on one-ton truck bodies for mobile fire protection at airports, oil fields, dock yards, utility stations, and for use by industrial and municipal fire departments. The unit comprises six 75-pound capacity cylinders of carbon dioxide which are arranged to discharge



in two groups of three, through high pressure, flexible hose and a rapid flow multijet nozzle. The hose reel, atop the cylinder bank, permits flow of carbon dioxide, under its own power when released, from the cylinders through gas-tight piping into the hollow trunion of the hose reel, then directly into the hose and out the discharge nozzle. Any reasonable length of hose may be carried on the reel, which has a brake to prevent excess uncoiling.

For further information write Walter Kidde & Company, Inc., 40 East 34th Street, New York 16, referring by number to this PETROLEUM REFINER item.

Control Valve (Item 603)

Featuring The Foxboro Company's stabilflo valve, Bulletin 226B describes how the valve can be changed from "air to open" to "air to close," or vice versa, without removing the valve from its installation or shutting down the controlled flow. The reversible motor has forged steel motor housing and is similar in general appearance to the conventional stabiflo valve. To reverse the action of the valve motor, the housing assembly is removed, rotated for one quarter-turn, and replaced. This requires the removal and replacing of four bolts.

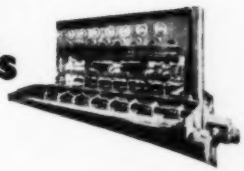
For a copy of the bulletin write The Foxboro Company, Foxboro, Mass., referring by number to this PETROLEUM REFINER item.

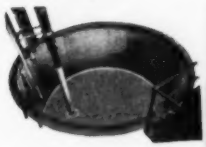
Plug Valve (Item 604)

The Durco type A valve, developed by The Duriron Company, Inc., and described in Bulletin 636, is a top lubricated valve for general chemical service at medium pressure. It combines bodies of corrosion resisting ductile alloys with hard corrosion resisting plugs of composite design. The lower part of the plug in the corrosive service is of hard alloys, duriron and durichlor. The shank is of stainless steel. Type B top lubricated valve has the lubricator in the plug shank, the bottom lubricated type B valve (used where plugs are too hard to machine readily) is provided with a lubricator in the body, below the plug. Type D, described in Bulletin 640, is the

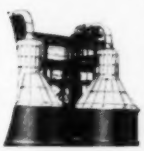
LEAD LININGS

...blunt the teeth of Hungry Acids

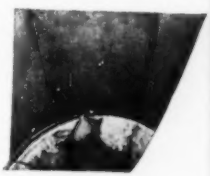




In unnumbered processing plants across the country, sheet lead plays a vital role in keeping acids under control. Because, among other unique properties given lead by nature, is *stern resistance to corrosion.*

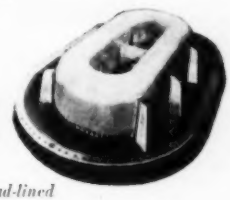


It is this innate ability to blunt the teeth of hungry acids, coupled with several of lead's other "abilities"—adaptability, workability, durability and availability—that makes the use of lead a virtual "must" as a lining for tanks, tubs and vats in which corrosive liquids are handled, moved or stored.



National Lead markets sheet lead of several types—chemical, antimonial, tellurium and antimonial-tellurium. Each has its functional place in the processing field. All are produced with a know-how that makes the most of the metal's inherent qualities. From starting slab to sturdy sheet, the rolling is done under the watchful eyes of experienced operators. The sheet comes off the cutting table smooth, uniform, and true to weight and dimensional specifications.

If your acid-handling activities demand lead's unusual combination of properties, use National Lead sheet. And if you would like our views on ways and means of getting optimum results from sheet lead installations, consider us at your service.



Look to the Leader for Lead

..in everything from lead pipe...valves...sheet...and lead-lined or lead-covered equipment...to complete acid recovery plants

NATIONAL

Lead Company

New York 6; Baltimore 3; Buffalo 2; Chicago 8; Cincinnati 3; Cleveland 11; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Company of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Philadelphia 25 (John T. Lewis & Bros. Co.); Atlanta (Georgia Lead Works, Div. of Cincinnati Branch); Toronto, Canada (Canada Metal Co. Ltd.).

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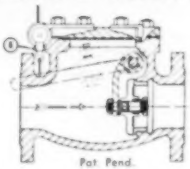
Don't gamble with fire in your plant or on your rig. Fire arrested in time saves lives, equipment, money.



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SWING CHECK VALVE

Here at last is a patented swing check valve that won't knock or chatter. Will outlast ordinary check valves many times. Gate mounted on vertical pin instantly swings into closed position when flow ceases or is reversed. Each valve factory tested.

GET BULLETIN 105 for full details on above Valves.

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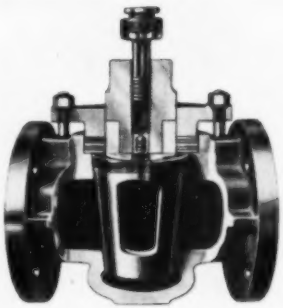
Export Representative: Guy E. Daniels, 30 Rockefeller Plaza, New York 20, N. Y.

New Equipment



high silicon iron lubricated plug valve which permits loading with stick or bulk lubricant.

For copies of the bulletins write The Duriron Company, Inc., Dayton 1, Ohio, referring by number to this PETROLEUM REFINER item.

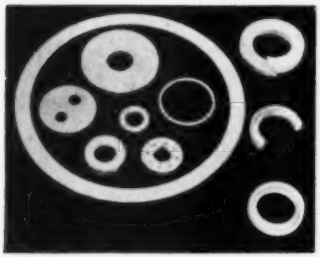
Sump Pump (Item 605)

The series MC sump pump, manufactured by Penberthy Injector Company, has underwriters' approval for hazardous locations including atmospheres containing metal dust, carbon black, coal or coke dust, grain dust, gasoline, naphtha, alcohol, acetone, lacquer, solvent vapors and natural gas. Motor leads are connected to switch terminals through threaded conduit as required by National Electric code. Switch housing has ½-inch pipe size threaded outlet for connection to line. Motor and switch are enclosed and explosion-proof. This sump pump, made of copper and bronze, has a capacity of 4000 gallons per hour, and will operate against a 23-foot discharge head. These series MC Penberthy automatic electric sump pumps are built in 5 lengths for sump depths of 2, 3, 4, 6 and 8 feet. All lengths are available for 110 volt, 60 cycle, or 220 volt, 60 cycle current from stock.

For further information write Penberthy Injector Company, 1242 Holden Avenue, Detroit 2, referring by number to this PETROLEUM REFINER item.

Packing Material (Item 606)

Crane Packing Company has announced that its new chemically inert packing material, Chemlon, is now available in molded form which retains all of the chemically inert properties of the familiar braided packing. "It is not attacked by any acids or alkalis, stands up for long periods of time and is effective to temperatures of 450° F." When split, the packing rings can be twisted and placed directly on the shaft without the necessity of completely removing the gland. Molded forms available include



washers, bushings, rings, self sealing "V" crossection rings, ring gaskets, and jacketed (French) gaskets.

For further information write Crane Packing Company, 1800 Cuyler, Chicago, or Crane Packing Company, Ltd., 122 Wellington Street, North, Hamilton, Ontario., referring by number to this PETROLEUM REFINER item.

Chemical Pumps (Item 606)

Milton Roy Company has developed four new units. The "Titronic" pump and automatic concentration control system, described in Bulletin 912, affords continuous concentration control in caustic or acid baths. The "Constametric" pump (Bulletin 649) is a duplex plunger type positive metering unit that discharges in a straight line flow free from pulsations. An adjustable stroke plunger type pump, powered by an air cylinder, is applicable for use where a number of liquid streams must be pumped in precise ratio to each other, where electrical current is not available, where explosion hazards are present, and for high-pressure services. The new Triplex pump with liquid ends of basic double ball check design, is designed for chemical pumping services at higher capacities and greater pressures than are possible with the company's standard pumps.

For copies of the bulletins write Milton Roy Company, 1300 E. Mermaid Avenue, Chestnut Hill, Philadelphia 18, referring by number to this PETROLEUM REFINER item.

Hydraulic Guillotine (Item 607)

The new Manco Manufacturing Company "Guillotine" with shear-type cutting blade is claimed to be the only portable hydraulic hand tool ever developed capable of cutting both wire rope up to 1¼ inch and mild steel rod up to ¾ inch. It can also be obtained with special center-cut blades for rod only, which will cut ¾-inch reinforcing and 1-inch mild steel. The guillotine, which weighs 40 pounds, can be adapted to perform crimping, swedging, and bending operations on large-diameter material. Heavy-duty design features special forg-

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Return to P. O. Box 2608 Houston 1, Texas

ings and high-tensile steel castings. The guillotine operates by hand pumping, using the operator's weight not strength to make the cut.

For further information write Manco Manufacturing Company, Bradley, Ill., referring by number to this PETROLEUM REFINER item.

Float Valves (Item 608)

O. C. Keckley Company's bulletin describes its No. 14 single seat, No. 15 balanced float valves, for the oil industry and the No. 20 float boxes with control valve.

For a copy write O. C. Keckley Company, 400 West Madison Street, Chicago 6, referring by number to this PETROLEUM REFINER item.

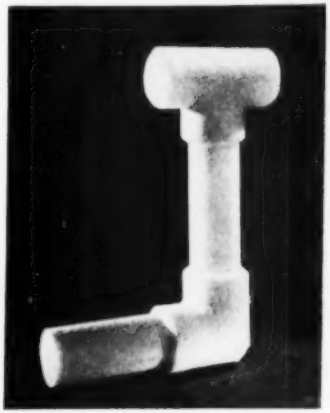
Reinforcement Bars (Item 609)

Bulletin No. 49 of Wallace Supplies Manufacturing Company, contains specifications, descriptions and data on pipe and tube, reinforcement bars, sections and structural shapes bending machines, both hand and hydraulic operated. It also has illustrations of sample bends and special built bending machines.

For a copy write Wallace Supplies Manufacturing Company, 1300 Diversey Parkway, Chicago 14, referring by number to this PETROLEUM REFINER item.

Cold Pipe Insulation (Item 610)

A light-weight pipe and vessel insulation, known as K-Shield, has been developed by Robinson Industries for cold pipe insulation. Application consists of a "simple covering procedure." K-Shield is made of styrofoam, an expanded plastic containing thousands of minute



closed-wall cells. It weighs approximately 1¾ to 1½ pounds per cubic foot. High moisture-vapor resistance, resistance to mold growth, rot and decay are other properties. The insulation is being used on pipe lines where temperatures range from 175° F. to minus 250° F.

For further information write Robinson Industries, Coleman, Mich., referring by number to this PETROLEUM REFINER item.

Shelving (Item 611)

Savings obtained from efficient shelving layout are described in a bulletin of The Frick-Gallagher Manufacturing Company. Types of Rotabin rotating units are shown used singly or in combination with straight shelving or counters. Also explained are types of straight steel shelving.

For further information write The Frick-Gallagher Manufacturing Company, 401 Shubert Building, Philadelphia 2, referring by number to this PETROLEUM REFINER item.

Chlorine Safety Chart (Item 612)

A new chart, "Recommendations for Safety in Use and Handling of Liquid Chlorine Cylinders and Ton Containers" has been prepared by Hooker Electrochemical Company. The wall chart lists recommendations for storage, handling and use of liquid chlorine cylinders, as well as emergency, first aid and prophylactic measures.

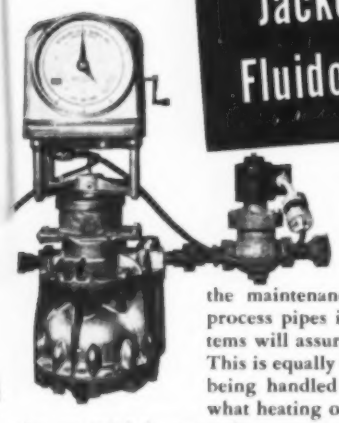
For a copy of the chart, write Hooker Electrochemical Company, Niagara Falls, N. Y., referring to this PETROLEUM REFINER item.

Steam Trap Drainage (Item 613)

A development in steam trap construction, called "Duo-Step Leverage," has been introduced by The Clark Manufacturing Company. By using a double fulcrum point and venting mechanism to increase the drainage capacity of a

Complete

Jacketed Pipe and Fluidometer Systems



For all Liquid Handling Problems

In any processing operation where the maintenance of a uniform temperature in the process pipes is necessary, H & B jacketed pipe systems will assure dependable, economical production. This is equally true regardless of whether the material being handled requires a hot or cold temperature, what heating or cooling medium is used, or whether the material is corrosive or non-corrosive. Write for Bulletin S-47.

The Fluidometer—If you have a liquid batching problem—involving either light or heavy liquids—investigate the Fluidometer System. The H & B Fluidometer is an accurate, dependable, completely automatic metering system adaptable to practically every liquid measuring problem in industry, whether it involves gallons, barrels or tank cars. Write for new Bulletin FL-49.

HETHERINGTON & BERNER INC.

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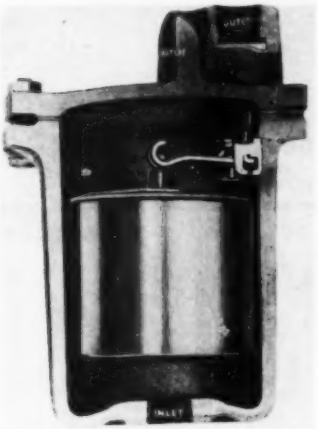

trap, the makers claim to have doubled the condensate handling capacity formerly possible. Steam trap users may buy smaller, less expensive traps to accomplish specific drainage jobs.

For further information write The Clark Manufacturing Company, 1830 E. 38th Street, Cleveland, Ohio, referring by number to this PETROLEUM REFINER item.

Shut-off Valves (Item 614)

A performance report on its positive shut-off valve for highly corrosive or penetrative fluids has been prepared by Sellers Injector Corporation. Applications of the valve and its design characteristics are presented in the report. Service performance, maintenance, safety and operational savings are also included. Photographs show several shut-off valves in different applications.

For a copy of Report 94 write Sellers Injector Corporation, 1600 Hamilton Street, Philadelphia 30, referring to this PETROLEUM REFINER item.

Fireproof Cement (Item 615)

Eagle-Picher Company's fireproofing cement with Underwriters' Laboratories, Inc.'s approval is claimed to retard the effect of great heat for three hours, when applied in a 1¼-inch layer. It is recommended for use in chemical plants, oil refineries, and other types of industrial installations where exposed steel work is part of the structure. It is sold as a gray, powdered material which is mixed with water to form a stiff paste and then troweled onto a ribbed metal lath wrapped around the steelwork to be protected.

For a brochure write Eagle-Picher Company, Cincinnati 1, referring by number to this PETROLEUM REFINER item.

Instrument Valves (Item 616)

New forged steel instrument valves built by Edward Valves, Inc., are described in Bulletin 491 for installation on small lines in petroleum and chemical processing plants. The valves are "small enough to fit into limited spaces and yet sturdy enough to withstand pressures as high as 6000 pounds." Constructed of

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SIMPLE • ECONOMICAL

Ring and fittings assembly for tank construction.

Externally removable manhead support.

Lenape elliptical access openings (straight rings or flued and curved saddles) and fittings, of the pressure loaded or "self-energized" type are produced in sizes ranging from 4" x 6" to 18" x 24".

Swing support gear, to carry cover inwardly or outwardly of the pressure vessel, as illustrated at the left, is particularly convenient where frequent access is necessary. Various other types are available.

Write today for our Bulletin 4-61 and current price schedule S-47 — feel free to call upon our engineering department to discuss design and fabrication problems with you.

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LENAPE HYDRAULIC PRESSING & FORGING CO.
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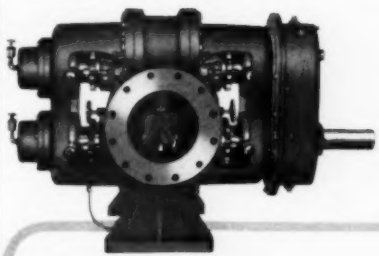
BIG MAN PRODUCTS



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In oil fields, refineries, and bulk plants, *Kinney Heliquad Rotary Pumps* are establishing outstanding records for dependable service. Special anti-friction bearings and separately lubricated timing gears maintain fixed rotor clearances for low-wear performance. Positive displacement pumping action is smooth and non-pulsating. Available plain or steam jacketed . . . for capacities to 3,000 bbls. per hour . . . for pressures to 375 p.s.i.

Write for Bulletin L-48 — address Kinney Manufacturing Company, 3596 Washington Street, Boston 30, Mass. Branches in New York, Chicago, Cleveland, Philadelphia, Los Angeles, San Francisco, Seattle, New Orleans, Houston.

We also manufacture Vacuum Pumps, Clutches, and Bituminous Distributors.

KINNEY Rotary PUMPS

When
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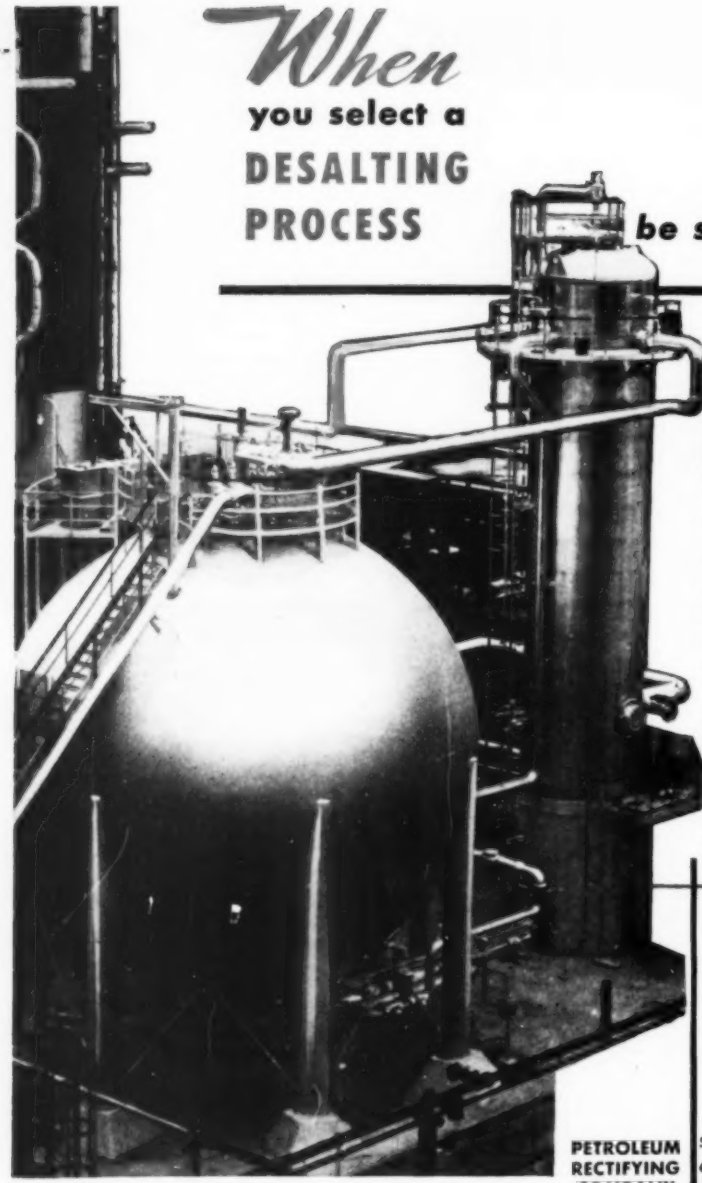
DESALTING
PROCESS

be sure you get

SERVICE



Why? Because every experienced refiner knows that any continuous process requires service if it is to continue to operate efficiently. Because of this, more refiners than ever before are specifying PETRECO DESALTING. With Petreco Desalting, *service is included* . . . the *best service know-how* available in the field of desalting today.

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SPECIALIZED *Electric* PETROLEUM PROCESSES { DESALTING / DEHYDRATING

PR-49-1

carbon steel, 13 percent chromium stainless steel, or 18-8 stainless steel, these new instrument valves are available in globe or angle design in ¼, ⅜, and ½ inch sizes with screwed or socket welding end.

For a copy write Edward Valves, Inc., East Chicago, Ind., referring by number to this PETROLEUM REFINER item.

Stainless Threading (Item 617)

The Cooper Alloy Foundry Company's folder on threading of stainless steel, entitled "Don't Fear Threading of Stainless," gives case studies, speeds, tool angles, coolants and other data. The folder is designed to show that properly trained personnel, using carefully selected equipment, can thread and tap stainless steel at high production rates and achieve uniformly high quality.

For a copy write The Cooper Alloy Foundry Company, Hillside 5, N. J., referring by number to this PETROLEUM REFINER item.

Fire Extinguisher (Item 618)

Ansul Chemical Company, Fire Extinguisher Division, has developed Model B, an improved line of dry chemical fire extinguishers for flammable liquid, gas and electrical fires. Features "with advanced engineering design" include threaded hose connections, swivel couplings on hose, stainless steel nozzle holder, corrosion-resistant nameplate, finger grips on cartridge guard, and water-tight construction.

For further information write Ansul Chemical Company, Fire Extinguisher Division, Marinette, Wis., referring by number to this PETROLEUM REFINER item.

Filter Masks (Item 619)

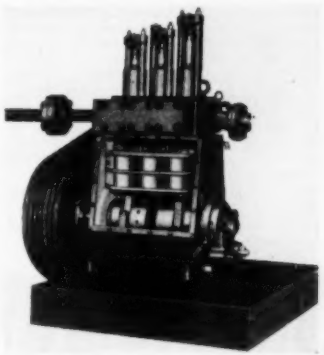
The Gogle Parts Company has developed a flex-a-foam filter mask for protection against non-toxic nuisance dusts. The mask which weighs only one ounce is of a honeycomb construction of whipped foam latex ventilated by tiny interconnecting cells that allow the passage of air but "keep out non-toxic dusts as small as 1/25000 an inch." Inner and outer frames are of Du-Pont's new polythene plastic. Headbands are molded of natural non-toxic, non-irritating rubber. All parts can be sterilized by washing in warm, soapy water and immersing in a mild formaldehyde solution.

For further information write The Goggle Parts Company, 1468 West Ninth Street, Cleveland 13, Ohio, referring by number to this PETROLEUM REFINER item.

Direct Flow Pump (Item 620)

"Practically any liquid encountered in oil field service, from light liquids to crude oil," can be handled by The Aldrich Pump Company's new series of five-inch stroke direct flow pumps. The series includes a triplex Pump with 3 cylinders, a quintuplex with 5 cylinders, a septuplex with 7 cylinders and a nonuplex having 9 cylinders. These pumps

New Equipment



range from 100 hp. with the triplex, to 275 hp. with the nonuplex. In this series all wearing parts are interchangeable except the main bearings. The outstanding feature of these Direct Flow pumps is the design and construction of the fluid-end.

For further information write The Aldrich Pump Company, Allentown, Pa., referring by number to this PETROLEUM REFINER item.

Anti Corrosion Pipe (Item 621)

Taylor Forge & Pipe Works, Inc.'s Bulletin 485, "Corrosion Service Piping," explains stainless steel and nickel alloy

Out of the Clark

RESEARCH LABORATORIES

comes the

BIGGEST STEAM TRAP NEWS in 50 years!

Clark DUO-STEP Leverage

Duo-Step Leverage — can save thousands of dollars annually for steam trap users ... in lower initial cost and greater drainage efficiency.

DUO-STEP LEVERAGE NOW AVAILABLE IN THESE CLARK STEAM TRAPS

"71-D", "80-D" SERIES & "1800-D"

"1900-D" SERIES

INCREASES TRAP DRAINAGE CAPACITY OVER 100%

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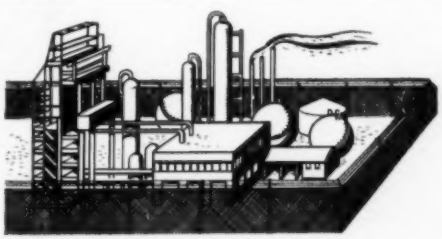

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CF&I

The Colorado Fuel and Iron Corporation

General Offices: Denver, Colorado

Pacific Coast Sales: The California Wire Cloth Corporation, Oakland, Calif.

anti-corrosion and anti-contamination piping. Economics, standards, advantages of welding, extensive technical data, design tips, and complete dimensional information on stainless fittings and flanges are included. The bulletin is particularly interesting and valuable at this time as the American Standard for Stainless Steel Pipe, ASA B36.19-49, has just been adopted by the American Standards Association.

For a copy write Taylor Forge & Pipe Works, Inc., Box 485, Chicago 90, referring by number to this PETROLEUM REFINER item.

Spiral Weld Pipe (Item 622)

Bulletin 493 of Taylor Forge & Pipe Works, Inc., describes spiral weld pipe and shows available sizes and wall thicknesses as well as fittings and flanges which are intended for use with the pipe. Typical applications listed include product lines, process steam piping, water lines, gas lines, and pumps and compressor house piping.

For a copy write Taylor Forge & Pipe Works, Inc., P. O. Box 485, Chicago 90, referring by number to this PETROLEUM REFINER item.

Safety Treads (Item 623)

New Products Development Corporation has manufactured "Tigerfoot" fall-preventing safety treads for slippery,

greasy, wet or icy floors, ramps, scaffolds, decks or yards. The treads can be fitted over and instantly removed from boot or shoe. These sandal-like attachments have soles of Behr-Manning "foothold" fabric.

For further information write New Products Development Corporation, 2080 Grand Boulevard, Scenectady, N. Y., referring by number to this PETROLEUM REFINER item.

Hydrocarbon Mixture (Item 624)

Phillips Petroleum Company has developed a new series of hydrocarbon mixtures of known composition designed for standardizing equipment, for checking the calibration of infrared, ultraviolet and mass spectrometers and low-temperature fractionation equipment, and for testing the accuracy of analysts. Exact blending compositions, accurate to ± 0.05 weight percent, will be furnished with each order. All six mixtures, numbering 31 through 36, are shipped in one-quart steel cylinders. Price and availability will depend upon composition and quantity required. Special blends are available.

For further information write Phillips Petroleum Company, Chemical Products Department, Bartlesville, Okla., referring by number to this PETROLEUM REFINER item.

High Vacuum Apparatus (Item 625)

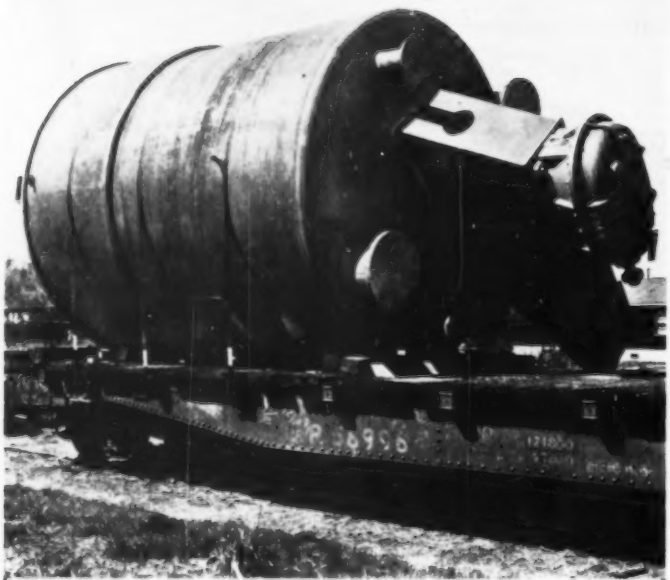
Central Scientific Company's booklet on its high-vacuum apparatus, includes suggestions for planning a high-vacuum system; information on pumping speed; explanation of merit factor, connections and speed of evacuation, low pressure technique, and other data, together with a complete listing of Cenco mechanical pumps, D-P diffusion pumps and Cenco gages, oils, traps and other vacuum accessories.

For a copy write Central Scientific Company, 1700 Irving Park Road, Chicago 13, referring to this PETROLEUM REFINER item.

Thermosetting Resin (Item 626)

A new thermosetting resin, Carbo-Fix, has been developed by Carboline Company for use as a corrosion resistant repair cement. The cement is said to resist attack by all the common corrosives, excepting sulphuric acid in con-

NICKEL CLAD KETTLE



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TANKS — KETTLES — FRACTIONATING COLUMNS
HEAT EXCHANGERS and SPECIAL EQUIPMENT
OF
STEEL — STAINLESS STEEL — NICKEL — MONEL
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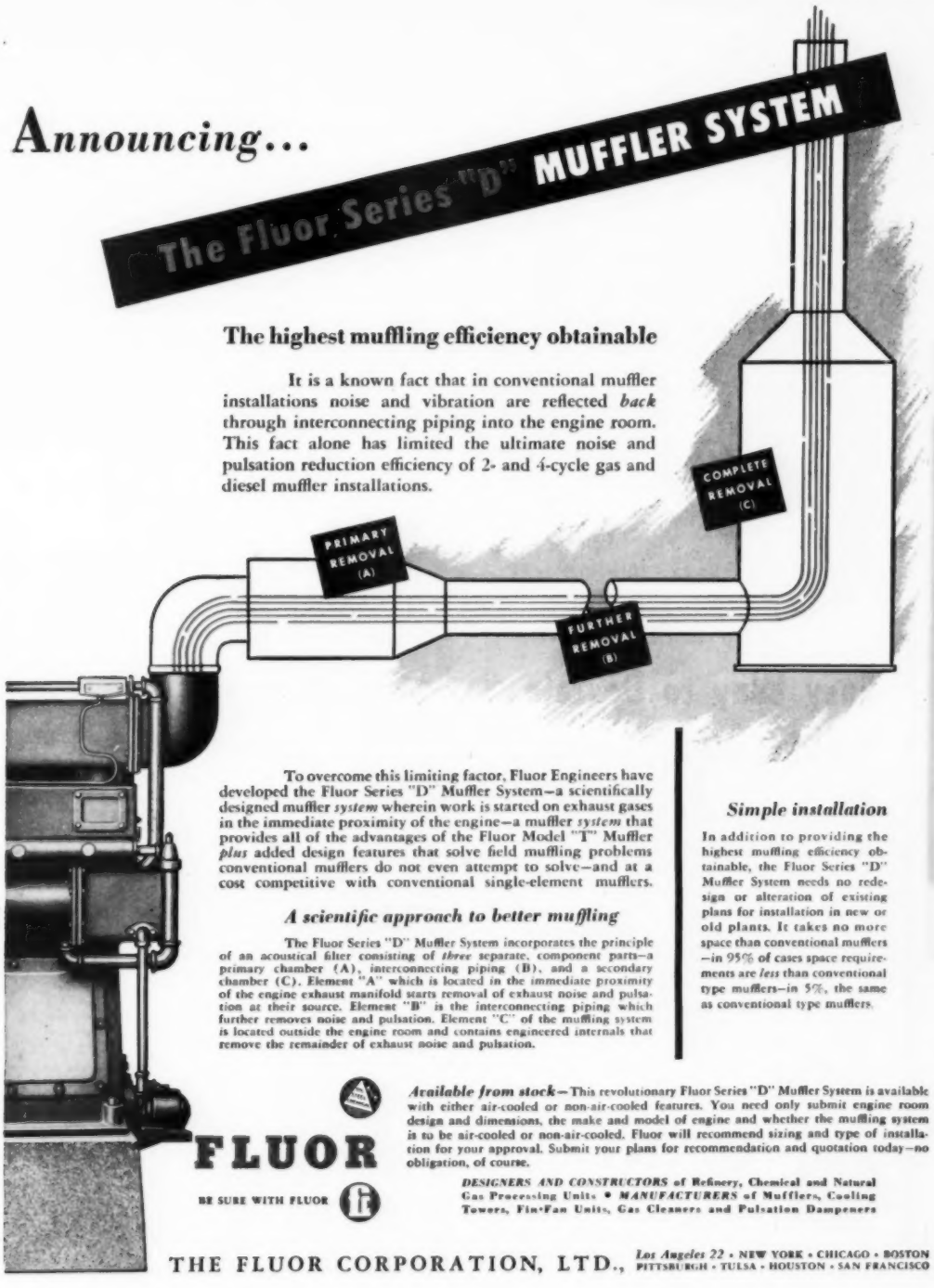
LEADER IRON WORKS, INC.
2170 N. JASPER DECATUR, ILLINOIS

Announcing...

The Fluor Series "D" MUFFLER SYSTEM

The highest muffling efficiency obtainable

It is a known fact that in conventional muffler installations noise and vibration are reflected *back* through interconnecting piping into the engine room. This fact alone has limited the ultimate noise and pulsation reduction efficiency of 2- and 4-cycle gas and diesel muffler installations.



To overcome this limiting factor, Fluor Engineers have developed the Fluor Series "D" Muffler System—a scientifically designed muffler *system* wherein work is started on exhaust gases in the immediate proximity of the engine—a muffler *system* that provides all of the advantages of the Fluor Model "T" Muffler *plus* added design features that solve field muffling problems conventional mufflers do not even attempt to solve—and at a cost competitive with conventional single-element mufflers.

A scientific approach to better muffling

The Fluor Series "D" Muffler System incorporates the principle of an acoustical filter consisting of *three* separate, component parts—a primary chamber (A), interconnecting piping (B), and a secondary chamber (C). Element "A" which is located in the immediate proximity of the engine exhaust manifold starts removal of exhaust noise and pulsation at their source. Element "B" is the interconnecting piping which further removes noise and pulsation. Element "C" of the muffling system is located outside the engine room and contains engineered internals that remove the remainder of exhaust noise and pulsation.

Simple installation

In addition to providing the highest muffling efficiency obtainable, the Fluor Series "D" Muffler System needs no redesign or alteration of existing plans for installation in new or old plants. It takes no more space than conventional mufflers—in 95% of cases space requirements are *less* than conventional type mufflers—in 5%, the same as conventional type mufflers.

Available from stock—This revolutionary Fluor Series "D" Muffler System is available with either air-cooled or non-air-cooled features. You need only submit engine room design and dimensions, the make and model of engine and whether the muffling system is to be air-cooled or non-air-cooled. Fluor will recommend sizing and type of installation for your approval. Submit your plans for recommendation and quotation today—no obligation, of course.

FLUOR

BE SURE WITH FLUOR

DESIGNERS AND CONSTRUCTORS of Refinery, Chemical and Natural Gas Processing Units • ***MANUFACTURERS*** of Mufflers, Cooling Towers, Fin-Fan Units, Gas Cleaners and Pulsation Dampeners

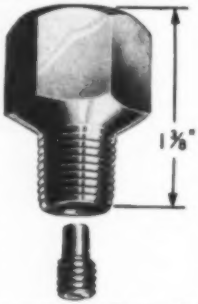
THE FLUOR CORPORATION, LTD., *Los Angeles 22* • NEW YORK • CHICAGO • BOSTON PITTSBURGH • TULSA • HOUSTON • SAN FRANCISCO

centrations above 45 percent and nitric acid. It is claimed to withstand heat to 350° F., and at this temperature to decompose very slowly but not to flow.

Further information on physical, mechanical and chemical characteristics, and on methods of application can be obtained by writing Carboline Company, 7603 Forsyth Boulevard, St. Louis 5, Mo., referring to this PETROLEUM REFINER item.

Cartridge Snubber (Item 627)

Helicoid Gage Division of American Chain & Cable Company, Inc., has developed a stainless steel cartridge snubber. Made with a cartridge of compressed powdered stainless steel and a steel body, it is a throttling device for pressure gages to reduce or eliminate pulsations of the gage pointer. No adjustments are needed. Specific porosity of cartridge makes it effective for required service—air, gas, water, steam or oil. It is available for all pressures up to 10,000 pounds. "Since this cartridge contains thousands of minute particles of stainless steel, the chances for clogging are considerably less than for the conventional snubber with a single, very small hole. Cartridges may be removed and cleaned, if necessary, or may be replaced."



For further information write Helicoid Gage Division, American Chain & Cable Company, Inc., Bridgeport 2, Conn., referring by number to this PETROLEUM REFINER item.

Oil Testing (Item 628)

A revised catalog, No. 699H, "Tag Oil Testing Instruments for Petroleum Products," has been published by C. J. Tagliabue Corporation. The catalog contains illustrations and specifications of the complete line of Tag, Tag-Saybolt, and the Tag-A.S.T.M. instruments for principal laboratory tests of petroleum.

For a copy write C. J. Tagliabue Corporation, 614 Frelinghuysen Avenue, Newark 5, N. J., referring by number to this PETROLEUM REFINER item.

Cooling Tower (Item 629)

A booklet containing hints on operating and maintaining water cooling towers, is being distributed by C. H. Wheeler Manufacturing Company. Included is the procedure for putting tower into service, inspection, lubrication, checking efficiency, and partial or total shutdown.

For a copy write C. H. Wheeler Manufacturing Company, 19th and Lehigh, Philadelphia 32, referring by number to this PETROLEUM REFINER item.

Electronic Filter (Item 630)

A new midget electronic filter has been designed by Trion, Inc., for cleaning air and gases on applications where the rates of flow are very small, usually in the order of only several cubic feet per minute. The filter, which operates on electrostatic principles, is recommended for use on laboratory pilot flows, pilot lines to gas burners using coke oven gas, and air lines to measuring instruments and other similar applications where dusts, condensates, gums, and other particulate matter must be precipitated. The filter is a standard "package" consisting of a filter unit and a power supply cabinet similar in size to a table model radio.

For further information write Trion, Inc., 1000 Island Avenue, McKees Rocks, Pa., referring by number to this PETROLEUM REFINER item.

Chemical Products (Item 631)

Black, Sivalls and Bryson, Inc.'s catalog entitled "Products for the Chemical Industry," includes descriptions of gas dehydrators, tubular heaters, indirect heaters, chemical feeders, gas scrubbers, wood and steel tanks, walkways and stairways, loading racks, safety heads, vent valves and valve-flame arrestor combinations. Thirty photographs and drawings accompany the data. Charts contain capacities, ratings and specifications.

For a copy write Black, Sivalls and Bryson, Inc., 720 Delaware, Kansas City 6, Mo., referring by number to this PETROLEUM REFINER item.

Flow Instruments (Item 632)

A variety of primary and secondary flow instruments and control valves for

Easy Way to Descale Debutanizer Condensers

DON'T waste valuable manhours dismantling condensers for scale removal! Use Oakite Compound No. 32, the inhibited acid descalant, which can be circulated through standing equipment.

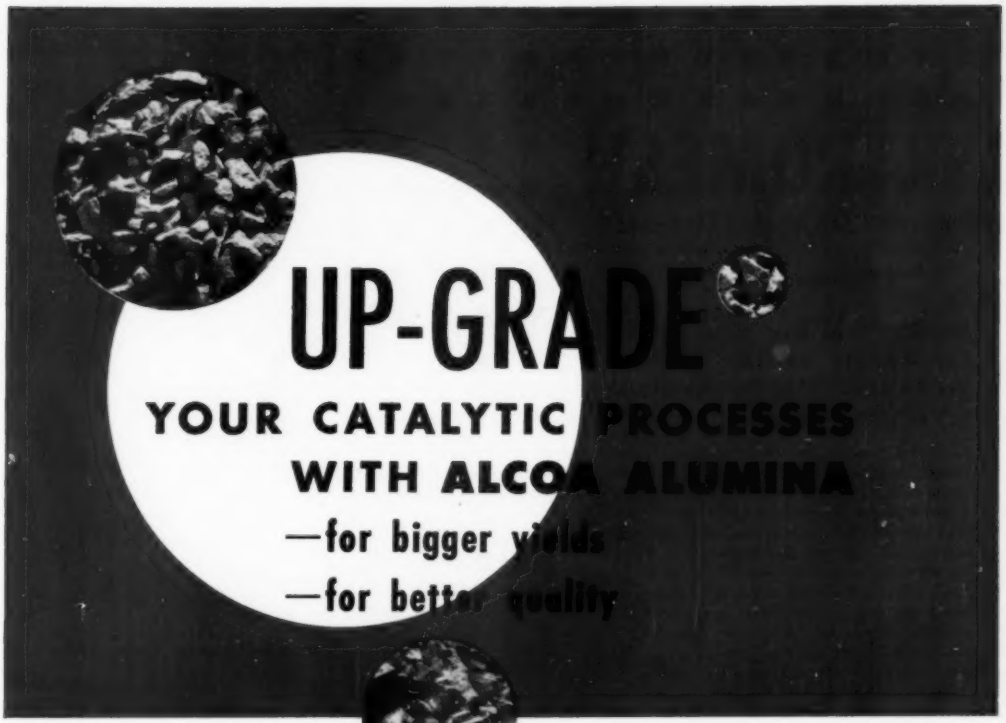
Here's all you need do: Pump-circulate a recommended solution of Oakite Compound No. 32. When descaling is complete, rinse and neutralize with an Oakite alkaline solution. You'll find Oakite descaling time-saving and safe. Why not talk it over with the Oakite Technical Service Representative near you. Or write direct for complete, free data. Oakite Products Inc., 50B Thames St., N. Y. 6, N. Y.

Technical Service Representatives Located in Principal Cities of United States and Canada

OAKITE 1909 1949 40 ANNIVERSARY YEAR

OAKITE
REG. U. S. PAT. OFF.
SPECIALIZED INDUSTRIAL CLEANING
MATERIALS • METHODS • SERVICE

KERLOW
KERLOW GRATINGS
For Every Industrial and Traffic Service
Come to Kerlow for every type of open steel grating for any purpose. Kerlow products include grid trays, walkways, floors, platforms, safety steps, tote boxes, pallets, drain grates, trench covers, bridge flooring, slabs and armoring. Light but strong and durable; self-clearing and fully ventilating, easy and economical to install and maintain.
Write for Catalogs on types of grating in which you are interested.
KERLOW STEEL FLOORING CO.
25 Mallory Ave., Jersey City 5, N. J.
KERLOW
OPEN STEEL FLOORING



If you want to up-grade your catalytic process yields, or simply reduce losses from contamination and side reactions, you'll find it advantageous to insist on ALCOA Aluminas for your Al_2O_3 catalysts and catalyst supports.

ALCOA Aluminas are uniform in structure and chemical purity . . . stable at elevated temperatures . . . have high resistance to erosion and crushing . . . and are moderate in cost. Typical conversions for which ALCOA Aluminas are used include: *Aliphatic hydrocarbons into aromatics, and dehydrogenation of naphthenic hydrocarbons.*

★ ALCOA *Activated* Alumina is preferred for many reactions because of its high adsorptive properties and extremely large surface area.

★ ALCOA *Tabular* and other forms of Alumina are preferred for certain reactions where hardness and extremely high purity are relatively more important than maximum surface area.

For top quality, specify ALCOA Aluminas for catalysts and catalyst supports. You'll get more efficient, uniform reactions and end-products of higher purity. We'll gladly send you samples and further information.

ALUMINUM COMPANY OF AMERICA,
CHEMICALS DIVISION, 1963L
Gulf Building,
Pittsburgh 19,
Pennsylvania

ALCOA

ALCOA CHEMICALS
ALUMINAS AND FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • LOW SODA ALUMINAS • TABULAR ALUMINAS • HYDRATED ALUMINAS
ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE

LEKTROMESH

THE UNIQUE SOLID-METAL SCREEN

Distinguished for its

STABILITY in Use
UNIFORMITY of Hole Size
WORKABILITY in Manufacturing Processes
DIVERSITY of Applications to Research and Production

Electro-deposited in pure copper, pure nickel, or nickel-on-copper — in regular commercial production with counts from 25 to 400 per inch—in lengths up to 100 feet and widths up to 36 inches—with tolerances on hole size and thickness suitable for the most critical uses—LEKTROMESH is ideal for precise filtration, for fabricated products such as fuel filters and electronic shields, even for distinctive decorative screens with an integral pattern. For full details let us send our Bulletin on LEKTROMESH. Address Department 16.

THE C. O. JELLIFF MANUFACTURING CORPORATION SOUTHPORT, CONN.

NO SCORE for centrifugals in any inning . . . when you pack with PALMETTO PALCO®!

On centrifugals pumping water or handling any neutral fluid to 275 F, there's no chance of scoring pump sleeves if the packing is Palmetto Palco.

Palco won't score because it can't score. Built of cotton roving, each strand is separately saturated with a Palmetto lubricant that provides a *self-lubricating* packing. Friction created is negligible.

Available in coil or ring . . . plaited square to required sizes. Write today for full particulars on this and the full line of Palmetto packings for all industry.

GREENE, TWEED & CO.
NORTH WALES, PENNSYLVANIA

Contact your fully-stocked Palmetto distributor on all packing problems . . . ask him about our special tools.

New Equipment

many industries, is described in Catalog 50 offered by Fischer & Porter Company. Descriptions include variable-area primary flow meters, frictionless, series-resonant circuit electrical transmitters, "Rato-matic" flow rate recorders, controllers, and ratio controllers, "Rato-Count" totalizers, "Accuro-Batch" control systems, and "Magna-Bond" Flowrator direct-connected recorders, controllers and pneumatic transmitters.

For a copy write Fischer & Porter Company, 50 County Line Road, Hatboro, Pa., referring by number to this PETROLEUM REFINER item.

Cone Roof Tanks (Item 633)

The second edition since 1946 of a technical report on "Evaporation Losses from Cone Roof Tanks," by R. C. Ulm, of the Graver research and development department, has been released. Discussion covers vapor concentration in cone roof tanks, breathing losses, and filling losses with a summary of conclusions. The book contains formulae for figuring vapor concentration and losses and includes graphs and photographic illustrations.

For a copy write Graver Tank & Manufacturing Company, Inc., East Chicago, Ind., referring by number to this PETROLEUM REFINER item.

Impeller Pumps (Item 634)

De Laval Steam Turbine Company's Catalog 1550 describes opposed impeller pumps which are available in pressures up to 1000 psi. Complete descriptions of both two and four stage units, along with rating, size and dimension tables are also contained in the catalog. The pumps are claimed to be particularly suitable for refinery boiler feed, pipeline, mine drainage, water supply, descaling spray and general hydraulic service.

For a copy of the catalog write De-Laval Steam Turbine Company, Trenton 2, N. J., referring by number to this PETROLEUM REFINER item.

Portable Pipe Threader (Item 635)

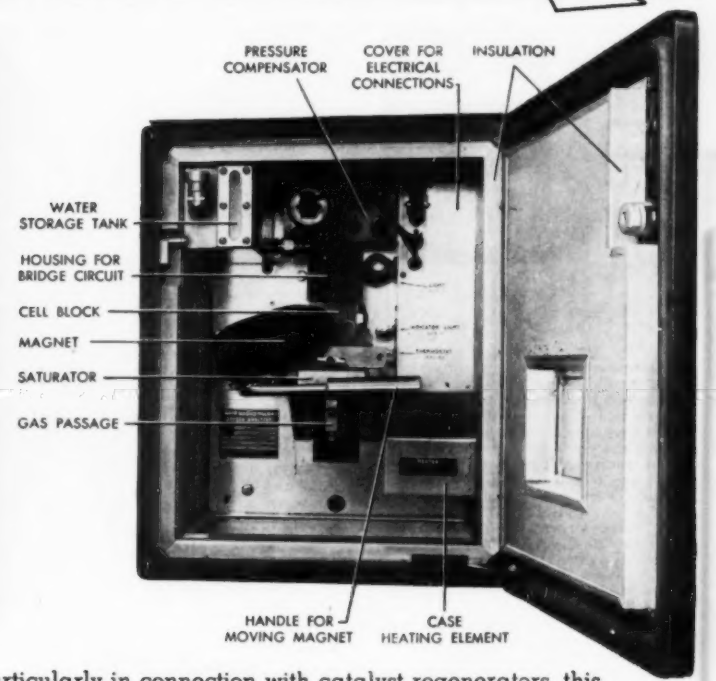
Porta-Drive, a new portable pipe threader was designed to fit in the average tool box, weighs only 14 pounds and it is claimed that one man operating it can thread up to 6-inch pipe in horizontal, vertical or other positions.

A 20 to 1 gear reduction unit, Porta-Drive can be driven by a ½ horsepower,

Here's the accurate, dependable OXYGEN METER

that the oil refineries have been waiting for

The **HAYS** MAGNO-THERM **OXYGEN ANALYZER**



Particularly in connection with catalyst regenerators, this Oxygen Meter has been tested and proved in service to measure oxygen with sustained accuracy and dependability.

Operates on an entirely new principle based on the paramagnetic property of oxygen. No combustion required—no fuel has to be added. Temperature of gas analyzing cell is too low to support combustion, which is a strong safety feature.

One large refinery superintendent says, "After testing several oxygen meters, we find the Hays meter to be operating on the best principle. We like its simplicity, its design, its method of operation, and its rugged construction."

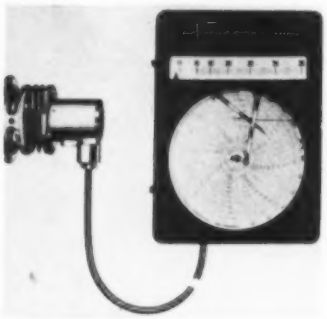
The interesting story of the Hays Oxygen Meter, including the electronic type recorder, is told in Bulletin 48-829. Write for it today.

THE HAYS CORPORATION
COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

heavy-duty electric drill and attached to standard set of dies by specially designed adaptor-yokes. An aluminum casing houses a bull gear and cold rolled spur gears, all sealed in grease.

For further information write Muncie Gear Works, Inc., Muncie, Ind., referring by number to this PETROLEUM REFINER item.

Radiation Pyrometer (Item 636)



A pyrovisor radiation pyrometer, designed for indicating, recording, or controlling temperatures up to 4000° F. in furnaces and kilns, is described in The Bristol Company's Bulletin P1242 which explains the unit's features and the theory of radiation pyrometry. Also included are accessories offered to adapt the unit for use with furnaces and kilns.

For a copy write The Bristol Company, Sales Promotion Department, Waterbury 20, Conn., referring by number to this PETROLEUM REFINER item.

Roller Bearings (Item 637)

Link-Belt Company is offering a catalog and engineering data book, No. 2550, covering the company's complete line of ball and roller bearings. The book gives construction features, list prices, weights, load ratings and dimensions for various standard models available. "The selection of the right bearing for the specific service has been greatly simplified." Selection examples and drawings of typical applications are included. Also described are welded steel base plates, lubrication fitting data, maintenance and lubrication, shafting, quality-controlled bearing manufacturing facilities.

For a copy write Link-Belt Company, 307 N. Michigan Avenue, Chicago 1, referring by number to this PETROLEUM REFINER item.

Cleaning Methods (Item 638)

How latest, improved cleaning materials and methods combine to reduce operating costs and assure more efficient performance from equipment employed in the producing, refining, transporting and marketing divisions of the petroleum industry is reviewed in a booklet published by Oakite Products, Inc. Specific materials and methods are discussed for cleaning absorption, stabilizing and fractionating towers, cleaning and descaling heat exchange equipment, cleaning and reconditioning oil drums and barrels, salvage cleaning and reclamation, cleaning and paint stripping storage tanks, and cleaning tank car interiors.

For a copy write Oakite Products, Inc., 150B Thames Street, New York 6, referring by number to this PETROLEUM REFINER item.

Pump Care (Item 639)

Covering all makes of centrifugal pumps, "Handbook for Care of Centrifugal Pumps," Bulletin 08X6256A of Allis-Chalmers Manufacturing Company, describes the how and why of pump construction and the effect on pump maintenance. How to figure head, and tables to help determine total friction loss are included. Causes and cures for sources of trouble such as too much power, not enough pressure, no water, or too much water delivered are offered along with a new maintenance timetable.

For a copy write Allis-Chalmers Manufacturing Company, 1062 S. 70th Street, Milwaukee, Wis., referring by number to this PETROLEUM REFINER item.

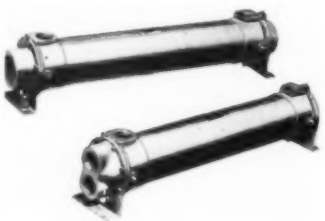
Telemetering Systems (Item 640)

Bulletin GEA-5233 describes General Electric Company's telemetering equipment for electric power distribution and industrial applications.

Included is information on the company's frequency type, torque-balance-type, and photoelectric-type telemeters. Wiring diagrams of typical telemetering installations for various services, and descriptions, dimensions, and specifications of telemeters and auxiliary equipment, such as torque-balance converters and torque-balance load injectors are also offered.

For a copy write General Electric Company, Schenectady 5, N. Y., referring by number to this PETROLEUM REFINER item.

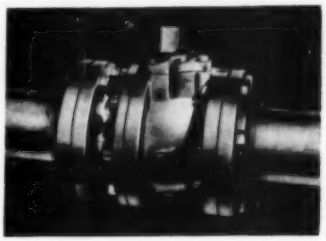
Heat Exchangers (Item 641)



Young Radiator Company's Catalog No. 1049 describes a new line of stock type "F" (fixed tube bundle) tube and shell type heat exchangers which are said to offer the economies of mass produced units, savings due to quantity purchases from standard sizes, as well as other savings. Designed to handle either fresh or salt water requirements, the line has been engineered for water to water and oil to water cooling in a wide range of applications such as marine engines, stationary diesels, torque converter cooling for buses and trucks, hydraulic presses, dynamometers, and transformers.

For a copy write Young Radiator Company, Racine, Wis., referring by number to this PETROLEUM REFINER item.

Cast Steel Valve (Item 642)



A 3 and 4-inch cast steel ball type valve for refinery, pipe line and general use has been manufactured by Rockwood Sprinkler Company. It is equipped with a floating ball and resilient, synthetic rubber seat, and "will handle fluids faster and more economically and will not leak after continued use." The valve can be opened and closed with a quarter turn. These new sizes have the same features of the ½ and 2-inch ball valves.

For further information write Rockwood Sprinkler Company, 38 Harlow Street, Worchester 5, Mass., referring by number to this PETROLEUM REFINER item.

Indicator, Tester Gauges (Item 643)

Two brochures describing and illustrating a superbronze non-corrosive indicating gauge and a combination deadweight gauge tester have been presented by Williams & Hussey Machine Company. The folder about the non-corrosive gauge describes types, ranges, construction details and improvements. The other folder gives construction details and operating instructions on each of the three types of gauge testers: single range, high pressure with reservoir; double range with reservoir; and single range, low pressure with reservoir.

For a copy of either brochure write Star Brass Manufacturing Company Division, Williams & Hussey Machine Company, Inc., Wilton, N. H., referring by number to this PETROLEUM REFINER item.

Process Engineering (Item 644)

Catalog No. CEC-49 of The Patterson Foundry & Machine Company lists the company's products and describes its activities in process engineering, from complete plants to individual machines. Grinding, mixing, classifying, processing, heat exchange equipment, hydrogenating, gas absorbing, and other units are described.

For a copy write The Patterson Foundry & Machine Company, East Liverpool, Ohio, referring by number to this PETROLEUM REFINER item.

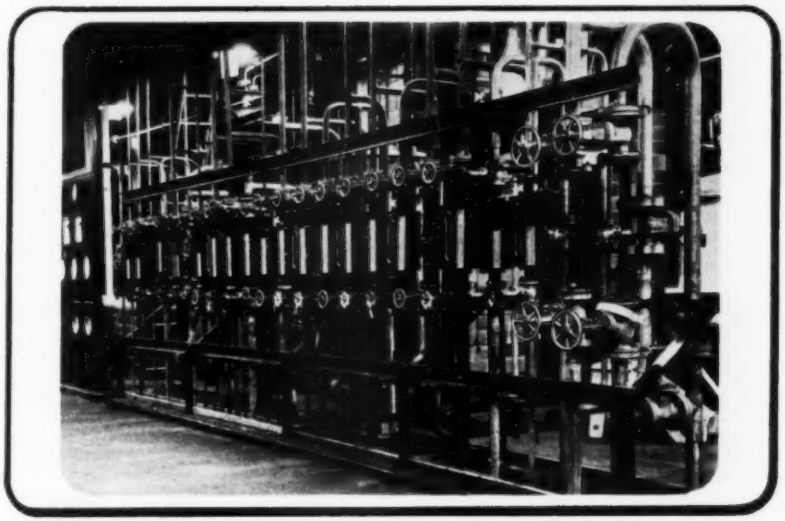
Rods and Electrodes (Item 645)

A new selector and comparison chart of hardfacing rods and electrodes, Bulletin CC-3, has been released by the American manganese steel division of American Brake Shoe Company. This chart lists each of the company's welding rods and electrodes and indicates its type of service. Metallurgical and physical descriptions of each rod are so arranged as to simplify selection.

For a copy write American Brake Shoe Company, 230 Park Avenue, New York 17, referring by number to this PETROLEUM REFINER item.

ALOYCO STAINLESS STEEL VALVES

recover spent acetic acid for *Hercules*



The photograph of the panel-board above was taken in the Parlin, New Jersey, Plant of Hercules Powder Company. It is part of their equipment for production of cellulose acetate. Because shutdowns for valve replacement are costly, it would be downright extravagant to use any but the best corrosion-resistant valves here.

That is why E. B. Badger & Sons Company, engineers and constructors, installed Aloyco Stainless Steel Valves in the first place.

The utility of Aloyco Corrosion-Resistant Valves is more than skin-deep. These Valves are not merely stainless-trimmed, they are made of solid alloy throughout, except for handwheels and yoke bushings. And they are made of the *one* right alloy for the particular job on which each is used. Aloyco metallurgical experience makes that assurance doubly sure.

Just name your corrosive—there's an Aloyco Valve "made to order" for it.

Aloyco Flanged V-Port Globe Valve No. 423, 150 lb., ½" to 4" inclusive. This metering valve is available in Aloyco 20, 18-8SMo and other corrosion-resistant alloys.

ALLOY STEEL PRODUCTS CO., Inc.

1303 W. ELIZABETH AVE., LINDEN, NEW JERSEY

SALES OFFICES: ATLANTA; CHICAGO; HOUSTON; LOS ANGELES; NEW YORK CITY; PITTSBURGH; WILMINGTON, DEL.

BOOKS of Current Interest

Acetylene Under Pressure

Acetylene and Carbon Monoxide Chemistry by John W. Copenhaver and Maurice H. Bigelow, is claimed to be the first critical treatment of the chemistry of acetylene under pressure, describing in detail all major chemical processes based on acetylene with particular reference to the newer developments in Germany, in this country and elsewhere. Available information up to 1949 has been included in the discussions covering the development of the chemistry of acetylene under pressure; the application of this new technique to the four major fields of vinylation, ethinylation, polymerization and carboxylation; the hazards involved; and the techniques and equipment which have been developed to insure safe handling. Newer phases of carbon monoxide chemistry are explained as are the many new or cheaper processes for producing high grade resins, synthetic oils and lubricants, natural and synthetic fuel gases, organic chemicals, synthetic rubbers and textile fibers. All processes have been checked by outstanding authorities and the authors for accuracy and authenticity.

Reinhold Publishing Corporation, 330 W. 42nd Street, New York, $10.00.

Liquid Fuel References

More than 725 individual references to Bureau of Mines investigations on the production of liquid fuels from oil shale, coal, lignite, and natural gas are contained in a revised bibliography on synthetic liquid fuel publications prepared by Norma Golumbic, Hazel C. Anderson, and Robert C. Grass, technical assistants in the Research and Development Branch, Office of Synthetic Liquid Fuels, Bruceton, Pa. Including all references listed in a bibliography issued by Bureau of Mines in May, 1945, the report also covers publications and reports appearing up to May, 1949. In addition to publications issued by Bureau of Mines in printed or mimeographed form, references are included to articles written by its scientists, engineers, and technologists for the technical press and to cooperative reports on work done jointly with states, colleges and industries.

Information Circular 7534, "Revised Bibliography of Bureau of Mines Investigations on the Production of Liquid Fuels from Oil Shale, Coal, Lignite, and Natural Gas (To 1949)," Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, free.

College Research Projects

Over 4000 current college and university research projects in engineering subjects, representing expenditures of over $35 million are listed by title in the 1949 **Review of Current Research** published by the Engineering College Research Council of the American Society for Engineering Education.

Entries in the book from 82 educational institutions which hold membership in the Research Council describe the administrative policies for conducting engineering research and list the responsible personnel, research expenditures, short courses and conferences of special interest, and the titles of all engineering research studies currently active at each institution. A breakdown of research projects according to the engineering departments involved, and by a complete index to research project subjects facilitate handling of the volume.

F. M. Dawson, chairman, care of the College of Engineering, State University of Iowa, Iowa City, Iowa, $1.75.

Light Hydrocarbon Data

Thermodynamic Properties of the Lighter Paraffin Hydrocarbons and Nitrogen, a monograph compiled by B. H. Sage and W. N. Lacey, has been completed and will be available around the first of the year, according to an announcement from the American Petroleum Institute's advisory committee on fundamental research on occurrence and recovery of petroleum. Orders may be filled now, however.

The work is a compilation of data resulting from a series of investigations of the lighter paraffin hydrocarbons and their mixtures, carried out by API research project 37 (California Institute of Technology, Pasadena) during the period 1930 to 1946. Included are studies of the volumetric behavior, heat capacity, latent heat of vaporization, heat of solution, and the Joule-Thompson coefficient of the pure hydrocarbons and some two- and three-component mixtures.

The thermodynamic properties of some of the systems, described in the studies, have been recalculated, utilizing, wherever, possible, more recent and precise measurements to supplement earlier data. Each system is explained in a separate section, consisting of descriptive text, tables, figures, and references.

Lacey Walker, American Petroleum Institute, 50 West 50th Street, New York 20, $7.50.

Pennsylvania Oils

The Pennsylvania Grade Crude Oil Association has published a booklet entitled **Facts and Figures That Prove the Superiority of Pennsylvania Oils.** Data, contributed by the association's technical advisory committee include discussions on oil consumption characteristics; pour point stability; the association's additive approval program; results of engine tests and field tests; and the Conradson carbon residue test. Importance is attached to the research program of the association which has been conducted for the past 20 years at the Pennsylvania State College.

API Tentative Standard

API's Tentative Standard 600 on flanged and welded end plug and valve gates consolidates Standards Nos. 600-A and 600-B, issued in 1942, and covering gate and plug valves respectively.

J. A. McNally, American Petroleum Institute, 50 West 50th Street, New York 20, $1.50.

Refractories Data

"Refractories," a book published by General Refractories Company, is intended for distribution to refractories consumers and designers and contractors of equipment employing refractory materials. It contains the history, manufacture and uses of refractories; research and technical production control; construction with refractories; brick tables; and a glossary of refractory terms.

The book also describes the manufacture of refractory brick from raw material selection to the finished product. A complete line of refractory brick, mortars, plastics and castables is explained. One section lists, with pictures and dimensions, all standard refractory brick sizes and shapes. Another deals with the properties and behavior of refractories.

Copies may be obtained at $5 each by writing General Refractories Company, 1520 Walnut Street, Philadelphia 2, referring by number to this PETROLEUM REFINER item.

Industry in Pictures

"Oil Pictures," prepared by Standard Oil Company of California for teachers and students in the West, is designed to portray pictorially the broad sweep of the petroleum industry. In sequence, the pictures illustrate the principal phases of the industry, including exploration, drilling, manufacturing plants, methods of transportation and distribution and some of the uses of petroleum products.

Synthetic Fuel

• CONTINUED FROM PAGE 85

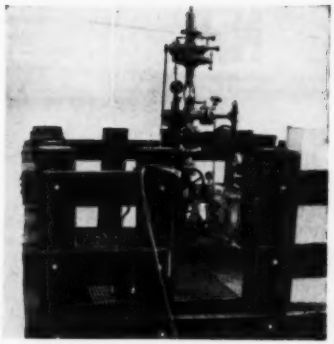
couraging initiative, subsidies could actually postpone the development of lower-cost techniques. If competitive development is retarded, the technology of synthetic fuels will not advance as rapidly as it should. Thus, when the time for synthetic fuels finally arrives, the nation will not be in as good a technological position as it might have been.

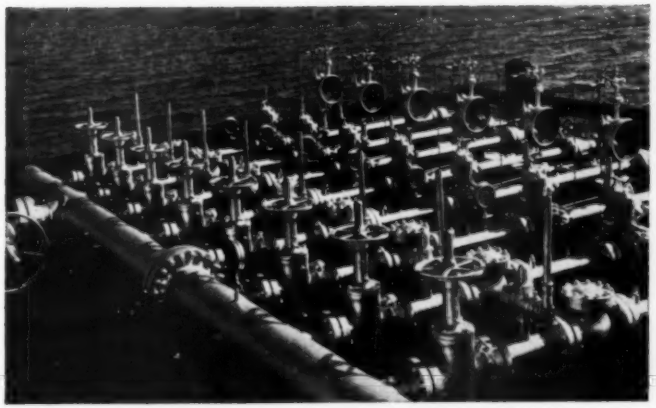
Summary

The national economy does not require synthetic production for at least another 10 years, even in the case of war. We should use the time between now and 1961 to advance the technology of synthetic fuels to a more mature state of development. We can do this by intensifying research on laboratory and pilot plant scales to improve present processes. By so doing, synthetic fuel plants can be made more efficient; investment costs can be lowered. Furthermore, the oil industry can accomplish these aims *without government subsidy.*

While government participation in the research work is advisable and should probably be increased, the building of "demonstration" or commercial plants would not only be undesirable but would also be extremely costly to the public. Finally, the petroleum industry has demonstrated its ability to meet the many problems that it has faced in the past. This successful record guarantees that it can also establish a synthetic fuel industry rapidly and efficiently—and at the proper time.

OFF-SHORE PRODUCTION AND GATHERING SYSTEM FOR NATURAL GAS

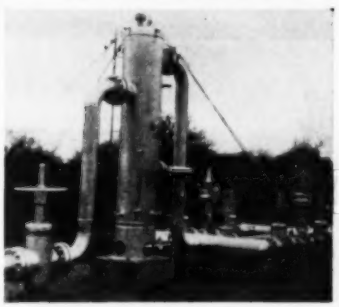


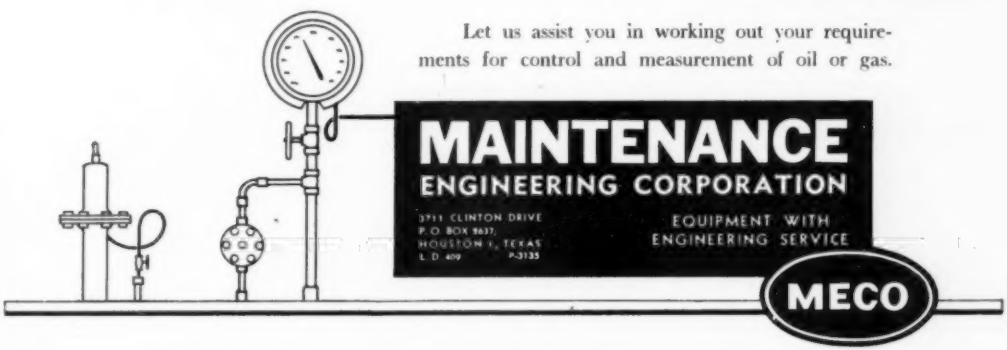


In the pictures:

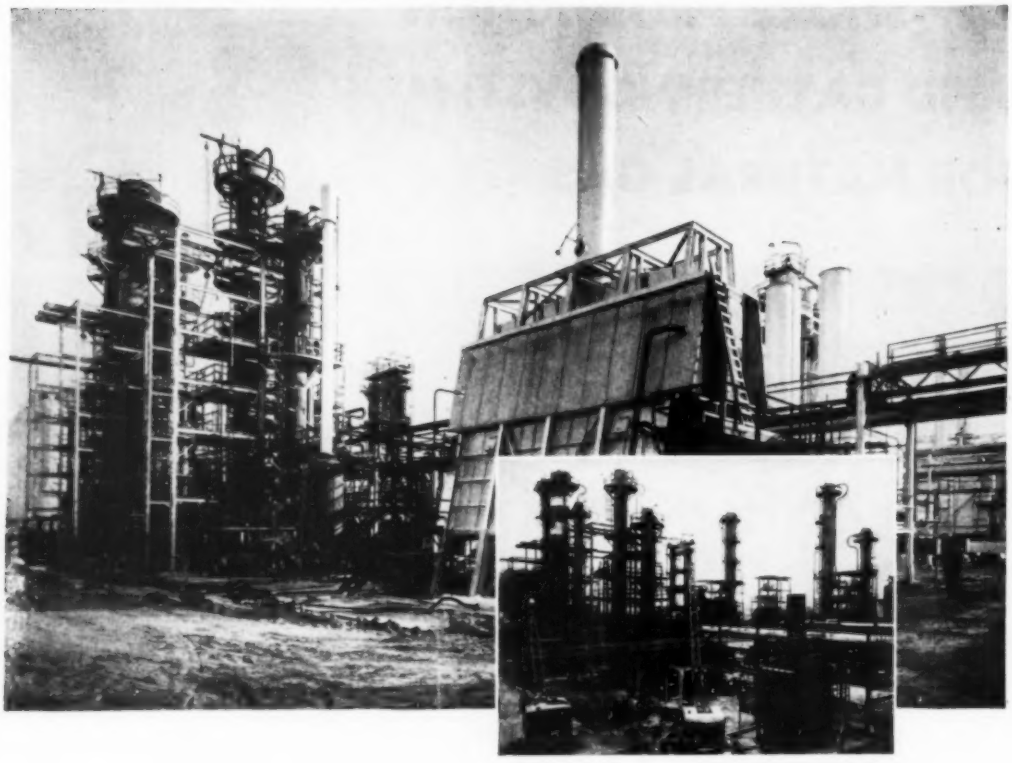
1. A producing gas well, one of eight in this particular Marine project. MASONEILAN Regulators control the pressure from each well and will also automatically shut in wells if lines should break.
2. The Meter Station at center of field 12 miles out in bay. 'MAINTENANCE' Meter Runs with COMMERCIAL Orifice Fittings and READING-PRATT & CADY Check Valves.
3. Control and Measurement Station on main line near plant site. Equipped with PEERLESS Separator MASONEILAN Regulators and Meter Run by 'MAINTENANCE.'

This Texas Gulf Coast installation is furnishing gas to a major industrial plant. The offshore location offered unusual problems which were met by close cooperation by our engineers during the design, layout and installation of this system as well as during start-up period. In addition to the specialty equipment shown, system also includes NORDSTROM Plug Valves, EDWARD Meter and Gage Valves, VOGT Forged Steel Fittings and TUBE TURN Flanges and Welding Fittings—all stocked by 'MAINTENANCE' at Houston and COASTAL ENGINEERING at Harvey, La.





N.B. While it is axiomatic that return on investment—the *ultimate earning power* of a refinery unit when actually on stream—is the only true evaluation of competitive engineering recommendations, initial plant costs remain a major factor in refiners' decisions on plant installations. M. W. Kellogg takes specific steps to *minimize initial plant costs* consistent with the achievement of *highest ultimate earning power*.



A CONVERSION THAT SAVED THOUSANDS

In modernizing refineries, it is naturally customary to convert existing equipment wherever possible. However, in a recent job for a mid-western refiner, Kellogg carried this construction principle to unusual lengths—with gratifying results in reduction of costs.

The refiner needed *complete* lube facilities. And he did not require an alkylation-isomerization unit which he already had. Kellogg took over this unnecessary unit—on the ground as it stood—and reengineered it.

Adding new equipment only when nothing was available for conversion, Kellogg transformed the unwanted unit into a modern lube plant, a plant employing vacuum distillation, propane fractionation, phenol treating, propane dewaxing and clay treating.

The small inset picture above shows the alkylation plant just as Kellogg started construction. The large picture, taken from the same angle just prior to completion, indicates the scope of the revision. It also shows clearly the utilization of existing equipment which saved this refiner a substantial portion of material costs, *a saving well into six figures*.

Any engineer knows that doing such a job and coming out with a truly efficient plant at the end is quite a trick. But it is an even greater trick to organize the work on the construction lot so that the savings gained through using existing equipment are not frittered away.

Such a task calls for the closest cooperation between engineering, scheduling, purchasing and construction. Completion of this successful lube plant with substantial dollar savings is additional proof of Kellogg's firm conviction that the integrated and complete organization is the only true approach to LOW INITIAL COSTS.

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About EQUIPMENT and SERVICE Suppliers

Minneapolis-Honeywell Adds to Factory Space

A one-story New York factory building containing 102,000 square feet has been purchased by Minneapolis-Honeywell Regulator Company from Champion Motors Company to accommodate expansion made necessary by stepped-up activity of the company's special products division which manufactures aeronautical control devices for commercial and military aircraft.

More than 300 employes will be transferred in November to the new location at 1433 Stinson Boulevard, which has 20,000 feet of office space and 5000 feet occupied by cafeteria, hospital and incidental facilities.

M. P. Fedders, who has been general superintendent of manufacturing at the company's Minneapolis plants since 1945, has been promoted to plant manager of the special products division. He joined Minneapolis-Honeywell Regulator Company in 1929 after graduation from the University of Minnesota, and has held various positions in the manufacturing and assembly departments, including managership of the ordnance plant operated by the company during war years.

Elliott Appoints Executives

Harry A. Erb has rejoined Elliott Company as assistant to the vice president in charge of engineering, and C. H. Hosterman, former manager of the accessories department, has been appointed manager of the general apparatus department. Erb, who joined the company in 1928, has for the past six years been steam turbine department service manager for Worthington Pump and Machinery Corporation. A graduate of Cornell University, he has served as blower engineer, manager of the service department and manager of the electric power department of Elliott Company's Ridgway division. His headquarters will be

The Patterson Foundry & Machine Company, East Liverpool, Ohio, has opened at Toronto, Canada, a new plant erected for the company's subsidiary, The Patterson Foundry & Machine Company (Canada) Ltd. The new plant has a floor area of 25,000 square feet, and is fully equipped to manufacture the company's complete line of industrial processing machinery and equipment. In addition to complete manufacturing facilities, the new plant will also maintain a process engineering division for the design of complete or partial process systems. This division will handle engineering, construction, installation and initial operaton of process systems, and will assist the research staffs of operating companies in the development of various processes.

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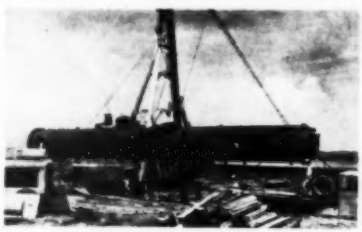

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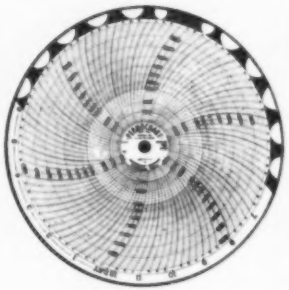

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WRITE FOR COMPLETE DETAILS

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Typical plant and laboratory equipment were shown in operation September 16-17 at an open house celebrating the opening of the new East Chicago, Ind., chemical, physical and metallurgical laboratories of Edward Valves, Inc., a subsidiary of Rockwell Manufacturing Company, manufacturers of cast and forged steel valves. Functions, operations and processes of the laboratory, pictured above, were described on tours through the plant.

at the company's main plant in Jeannette, Pa.

Hosterman, now handling sales of the accessories, heater, condenser and ejector divisions, joined Elliott Company in 1922. He is a graduate of Pennsylvania State College.

Coy Extends Sales Area

Joseph A. Coy Company, Inc., Tulsa, manufacturer of heat exchange equipment, has appointed Milton H. Roths as its representative in Houston. He will maintain the former company office at 4101 San Jacinto. Roth's appointment will enable the company to expand its sales engineering service for heat exchangers in the Houston area.

Graver Extends Operations, Announces Staff Changes

Henry T. Sulcer has been appointed general manager of Graver Water Conditioning company, New York, which was recently formed to extend the water treatment and liquid conditioning facilities of the company. Sulcer was formerly general auditor with the parent company which he joined in 1948. Edward W. Welp, former sales manager of Graver Water Treating Division, will make his headquarters in the Chicago office as assistant general manager. S. D. Barr, previously in charge of eastern district sales, has been named general sales manager with offices in New York.

Sulcer

Vincent J. Calise is heading the technical division of the company, which together with the expansion of the chemical and mechanical engineering staff and facilities, has been divided into sections specializing in boiler feedwater, conditioning, ion exchange systems, filtering systems, waste water disposal and reclamation systems, and sugar and food products processing equipment. These sections provide complete services in chemical analysis, design, engineering, manufacturing and erection of equipment.

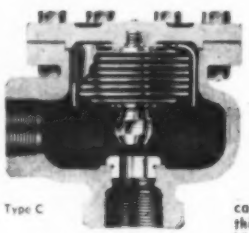
T. B. Leech Is Appointed Petro-Chem Sales Manager

Petro-Chem Development Company, designers and fabricators of furnaces, superheaters, and steam generators has

Nicholson Steam Traps

CUT KETTLE TIME 30%

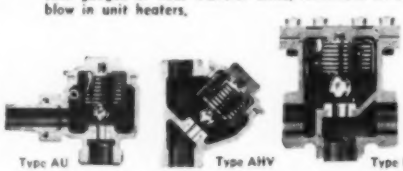
For Leading Processor



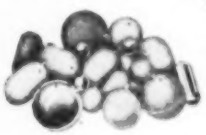
Type C

Records of a recent installation of Nicholson steam traps, by a large processor, show they cut kettle time 30%. For example, one operation was shortened from 65 to 45 minutes. Nicholson units keep equipment full of live steam because: 1) they operate on lowest temperature differential; 2) have 2 to 6 times average drainage capacity. Also record low for steam waste; and maximum air-venting capacity. Widely specified for preventing damage to thin gauges of heat transfer units; eliminate cold blow in unit heaters.

HIGH-PRESSURE FLOATS —Stainless, monel, steel or plated steel. Welded. In all sizes and shapes; for operating mechanisms and as tanks or vessels. 2-day delivery. BULLETIN 348



Type AU Type AHV Type B



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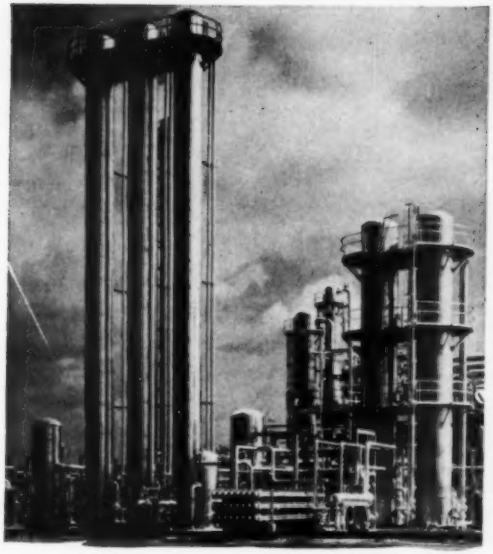

Southwest Gas Producing Co.—Uses

FLORITE

The recently completed gasoline plant of Southwest Gas Producing Company at Dubach, La., gathers wet gas from the surrounding area and employs new highly efficient methods for separating its ethane and propane components. Ninety million cubic feet of natural gas is handled daily, yielding a daily output of 230,000 gallons of liquefied hydrocarbons. The Fish Engineering Corporation of Houston designed and constructed this model plant.

In the two towers at the right of our illustration, wet gas is dehydrated with Florite and then passed to the three towers at the left for high-pressure absorption.

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Catalytic Chemistry

By HENRY W. LOHSE

Consulting Chemist, Fellow of the Royal Society of Arts, London; Canadian Institute of Chemistry; American Chemical Society; American Assn. for Advancement of Science.

CONTENTS

Chapter I. Brief History of Catalytic Chemistry
Chapter II. Catalytic Theory
Chapter III. Nature and Properties of Catalysts
Chapter IV. Specific Types of Catalytic Reactions
Chapter V. Industrial Catalytic Reactions

This book aims at a factual presentation of the underlying principles of catalytic phenomena and the application of catalytic reactions in industrial processes.

Particular attention has been paid to the presence of impurities in catalytic reaction systems, and to the role of traces of other metals in silver, copper, iron, nickel, etc., used as catalysts.

A separate section has been devoted to each of the various types of catalytic reactions. The nature and properties of catalysts, specific types of catalytic reactions, as well as industrial catalytic reactions have been discussed in detail.

Many clear illustrations will help in the understanding of little understood phenomena.

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appointed T. B. (Tom) Leech as sales manager. Leech went to work for The Texas Company in 1916 and for many years has been with engineering or engineering sales organizations handling refinery equipment. Since 1941, he has been manager of refinery sales for Bethlehem Supply Company, resigning from that position last August 1 to go with Petro-Chem.

Glitsch Promotes Manager

Gordon W. Lindskog, assistant manager of the New York office of Fritz W. Glitsch & Sons, Inc., Dallas, has been promoted to manager of the New York office. He succeeds Robert W. Fowler who moved to Dallas recently as general manager of sales.

Lindskog

Lindskog formerly worked for The M. W. Kellogg and National Transit Pump & Machine Co. He will handle the office which serves New York, Pennsylvania, Delaware, Maryland, the eastern seaboard and eastern Canada.

Unistrut Names Manager

Spencer R. Griffiths has been appointed assistant sales manager of Unistrut Products Company, Chicago. He was formerly associated with Joseph T. Ryerson and Son Incorporated, in charge of stainless steel sales in the midwest.

A new building for the Chicago offices and plant of H. Sargent & Company has just been completed. The company, with offices and plants in Chicago, Detroit and Dallas, manufactures and distributes scientific laboratory instruments, apparatus and chemicals. The one-story steel, concrete and brick building is located at 4647 West Foster Avenue, Chicago 30. The offices have acoustic ceilings and tile floor, and are fully air-conditioned. Adjacent to the general offices are a city sales room; lecture and projection room; scientific library; show room; first aid room and plant cafeteria with kitchen.

Bowman and Zuk Appointed Laclede-Christy Engineers

Edward W. Bowman and Alex Zuk have been appointed engineers in the arch and wall sales division of Laclede-Christy Company. Bowman will maintain headquarters in the company's general sales office, Pittsburgh. A graduate in mechanical engineering from the University of Toledo, he has had advanced study in heat treating and industrial furnace construction.

As his first position with Laclede-Christy, Zuk will have headquarters in the company's New York office. He was with Westinghouse Electric Corporation for ten years as engineer and Iorio Construction Company, Newark, N. J., for two years.

Canadian Firm to Manufacture Kerotest Cast Steel Products

Cast steel products of Kerotest Manufacturing Company, Pittsburgh, will be manufactured and distributed in Canada by Guelph Engineering Company, Ltd., Guelph, Ontario, Canada. This line of products, including pipe line valves, tank valves, refinery and industrial valves, cast and forged steel fittings, will be known and marketed as Acme-Kerotest and will be manufactured "in strict accordance with the company's drawings and specifications in their plant at Guelph, Ontario."

Allis-Chalmers Announces Norwood Department Changes

Max L. Murdock, acting manager of the centrifugal pump department at Allis-Chalmers Manufacturing Company's Norwood, Ohio works, has been promoted to manager of the department succeeding H. C. Gaton, who has retired. Woodrow Brixius, former application engineer in the company's west

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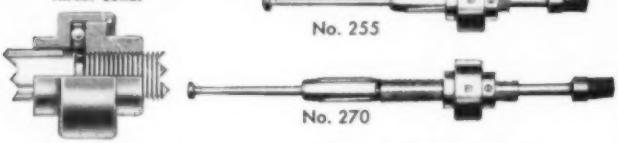

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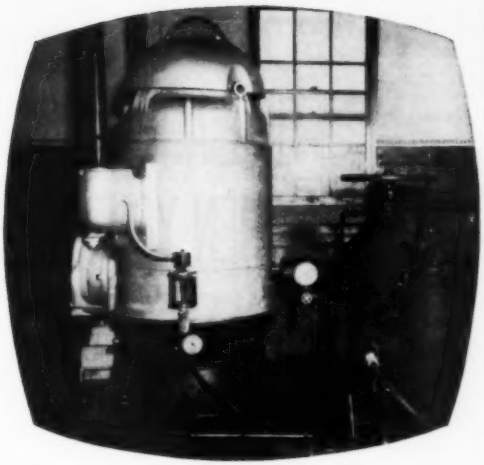

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Layne's "know how" omits guess work and patch ups in construction errors by the less experienced. After the installation has been accepted, you have the long established and responsible Layne organization on which you can depend for repairs, parts or service when and if ever needed. For further information, catalogs, etc.

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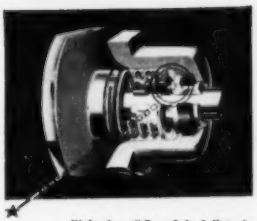
FACTORS IN SHAFT SEAL DESIGN BY JOHN CRANE

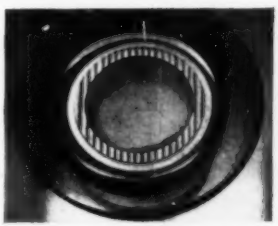
IMPORTANCE OF PRECISION SURFACES ON SHAFT SEAL MATING FACES



"John Crane" Type 2 Seal. Note, in circle, mating faces of sealing washer and stationary floating seat.

Successful operation of mechanical seals depends on the condition of the sealing faces. Today's speeds and pressures demand precision flatness of these mating surfaces because the sealing is done by the two mating surfaces, separated by a thin lubricant film. Unevenness in surfaces creates openings which allow foreign particles in the sealed liquid to work in between faces. They act as abrasives, causing wear and failure. *Only precision lapping generates surfaces smooth enough to form a film of sufficient thinness to exclude them.*

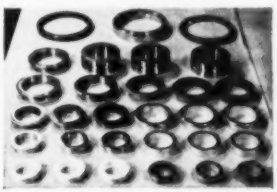
TWO OBJECTIVES FOR PERFECT MATING SURFACES



Floating seat for "John Crane" Shaft Seal under an optical flat, showing flatness less than 11.6 millionth inch.

Two main objectives are achieved by precision lapping: 1) Removal of hills and valleys (scratches and flaws); 2) Flatness of the whole surface area. The first measurement —known as RMS—is made in micro-inches, and indicates depth and height of hills and valleys. The second measurement is through optical flats. Often faces must be flat to 11.6 millionth of an inch—equivalent to one light band.

ALL "JOHN CRANE" MECHANICAL SEALS PRECISION LAPPED



Floating seats of ten different materials, as lapped by the "John Crane" Lapmaster.

All sealing washers and floating seats for "John Crane" shaft seals are precision lapped on "John Crane" Lapmasters, and rigidly inspected for required measurements. Precision finish for each seal is specified to handle working seal pressures. When you specify "John Crane" you are sure of finest quality surface finish and proper flatness for your application. Crane Packing Company's experience with surface finish and with all types of sealing problems can be a real help to you when your next sealing need arises.

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There are two good reasons why we stress Gordon Quality and Gordon Service. (1) The precision quality of Gordon Thermocouple Extension Lead Wire is based upon 32 years of experience in careful selection and inspection to meet rigid insulation requirements. (2) Gordon's Chicago and Cleveland plants carry complete stocks of Thermocouple Extension Lead Wire for practically every application. (See illustrations below.) This means that your order gets immediate delivery of a QUALITY product—one that meets Bureau of Standards Specifications. ORDER NOW! No waiting or delay. Prices available upon request.

CHROMEL ALUMEL, Cat. No. 1231[3-A], 14 ga., STRANDED-DUPLEX, each wire felted asbestos, Asbestos-yarn braid overall.

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Allis works centrifugal pump department, has been named assistant to Murdock, and Paul B. Hugenberg has been appointed application engineer in charge of sales and orders.

Murdock has been associated with the company since 1936. Brixius and Hugenberg joined the company in 1931 and 1940, respectively.

Du Pont Promotes Manager

David H. Conklin, west coast district manager for E. I. Du Pont de Nemours

Tyler

Conklin

and Company, Inc.'s petroleum chemicals division, has been promoted to assistant sales manager with headquarters in Wilmington, Del. George L. Tyler will succeed him as manager of the district office in Los Angeles.

Conklin, who will be one of two assistant sales managerships in the division, will be in charge of promotion activities. After receiving his bachelor of science degree in mechanical engineering at the University of Michigan in 1935, he was employed with Ingersoll-Rand Company and in 1947, joined E. I. Du Pont de Nemours and Company, Inc.

Fluor Promotes Manager

The Fluor Corporation, Ltd., of Los Angeles, designers, engineers, and constructors for the gas, petroleum and allied industries, has promoted Owen W. Gaudern to manager of purchases. Gaudern entered the purchasing field with Neilan Company of Los Angeles. In 1934 he joined The Fluor Corporation and a year later was transferred to the purchasing department, where, in 1946, he was assigned to Shell Oil Company's project at Vancouver, B. C. Prior to this promotion, he served as assistant manager of purchases for The Fluor Corporation.

Gaudern

Prufcoat Sales Manager

John G. Wild, specialist in the field engineering of synthetic resin coatings, has been appointed assistant sales manager of prufcoat Laboratories, Inc. of Cambridge, Mass., manufacturers of special protective coatings used in industries dealing with the problem of chemical corrosion.

Kerotest Elects Executives

William Frame and J. D. Isaacks, of Kerotest Manufacturing Company have been elected vice presidents. Isaacks has been named vice president in charge

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CR Aqua-Vactor Uses Water as Motivating Fluid

Combining the advantages of the steam jet ejector and the low cost of water, the Croll-Reynolds AQUA-VACTOR is employed economically in many instances. Low in first cost and with no moving parts, the water jet may be used to mix liquids, serve both as an ejector and condenser, and in isolated cases, handle air and gases.

While not as efficient as a steam jet ejector, the AQUA-VACTOR becomes economical when the pressure of water is being dissipated for other process work. In such cases it may be possible to use the AQUA-VACTOR either as an ejector alone or as both an ejector and a condenser using water under pressure to operate the AQUA-VACTOR and using the exhaust from the AQUA-VACTOR for other processes.

The illustration shows a type SW EVACTOR using steam in the first stage and water in the second stage. Here the AQUA-VACTOR is used both as an ejector and as a condenser, handling air and, at the same time, condensing steam from the first stage. Of interest to engineers with corrosion problems, the steam stage in the illustration is constructed of carbon including the steam nozzle. The carbon is incased in cast iron giving the equipment the strength of iron and the corrosion resistance of carbon.

For more complete information concerning the application of the AQUA-VACTOR, or any type of steam jet EVACTOR, write today to:

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Operators Say:

"Annin Domotor Valves Cut Maintenance Cost up to 83%"

Actual users who compared Annin Domotor Valves with other standard valves report savings of 83% in maintenance costs. They learned from experience that the built-in ruggedness and simplified maintenance features of Annin Domotor Valves assure long, efficient, trouble-free service.

Here are The Reasons:

THEY'RE SINGLE SEATED— Annin Domotor Valves are of proven, simplified single-seat design. The smooth, curved contour of the flow passages, without pockets or shoulders, provides free, uninhibited fluid flow for effective control of slurries, sludges and viscous fluids. Pressure drop and turbulence are reduced to a minimum and flow capacity greatly increased. The valve seat, clamped in position between the two sections of the separable valve body, absorbs all line stresses in shear for greater valve strength. Simplified construction cuts valve body weight by over 50%.

THEY'RE CORROSION AND EROSION RESISTANT— Annin Domotor Valves are available in the alloy that will give longest valve life under severe corrosive, erosive, or gaseous conditions. The wide range of alloys offered includes: Cast Carbon Steel, Cast Type 316 Stainless, Hasteloy B and C, Monel, Ampco 15, Annico 20 (D 20), Zinc Free Bronze, 98% "A" Nickel and almost any castable alloy. High velocity fluids are efficiently handled at temperatures from −300° F. to 1,000° F. and pressures to 2,500 lbs.

THEY'RE SIMPLIFIED FOR FAST, ON-THE-JOB MAINTENANCE— Any part of the Domotor valve body assembly or operating unit may be replaced or repaired while in the line, for maximum maintenance economy. Interchangeable line flanges make possible the use of a single valve anywhere in your plant, irrespective of system pressure. The separable valve body construction with threadless valve seat assembly permits immediate, on-the-job replacement or repair of the valve seat plug and stem without special tools or shop operations.

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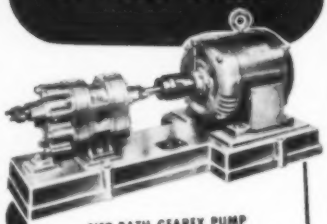

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Pumps: oils, varnishes, solvents, molasses, chemical solutions.

Capacities: 1-550 g.p.m.

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A notable feature of Sier-Bath Rotary Pumps is their relative freedom from down-time for repairs and maintenance. Built in a shop equipped for manufacture of the finest precision gears, Sier-Bath Pumps show surprising ability to stand up under the most rugged operating conditions. The value of such sturdy construction cannot be over-emphasized in these days of high operating costs.

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of steel valve sales, and Frame will serve in his former capacity of works manager in addition to his duties as vice president.

Frame joined Kerotest recently as works manager after 14 years with National Supply Company as works manager of their Spang Chalfant plant at Ambridge, Pa. Isaacks was formerly district manager for Kerotest in Houston.

New A. O. Smith Concern Names Officers and Directors

Officers and directors have been named for the new A. O. Smith Corporation of Texas. The new corporation, a subsidiary owned jointly by the A. O. Smith Corporation of Milwaukee and the Sheffield Steel Corporation, will build and operate a plant in Houston for the manufacture of large diameter welded steel pipe for oil and gas transmission lines and for oil well casing.

Smith

Officers of the new Texas corporation are A. von Wening, chairman of the board; L. B. Smith, president; Dennis F. McCarthy, vice president; J. M. Floyd, vice president; Morris J. Vollmer, secretary-treasurer, and Robert B. Heinzen, assistant secretary-treasurer.

The directors will include von Wening, Smith, Ray F. Bell, and W. C. Heath. These board members from Sheffield Steel Corporation include R. L. Gray, J. C. Shepherd, F. R. McFarland, and L. H. Juengling.

Dravo Agent Named

F. W. Morris, 505 Capitol Building, Tulsa, has been appointed representative for Dravo Corporation, Pittsburgh, in the fabrication and erection of fabricated piping for industrial plants, oil fields, central utility stations, waterworks, gas transmission systems and other services. Morris' territory includes Oklahoma, Louisiana, Arkansas, Texas, New Mexico, Kansas, Colorado and Missouri with the exception of the county of St. Louis. He previously was district manager at Tulsa for Spang-Chalfant Division, National Supply Company.

Morris

Belfield Adds to Sales Staff

Belfield Valve Division of Minneapolis-Honeywell Regulator Company has added to its regional field sales staff in an expanded national sales and manufacturing program directed to manufacturing and processing industries as follows: Russell A. Schegel for the eastern region, headquarters in Cleveland; Robert Scott in the midwest and northwest regions, headquarters in Chicago;

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OIL HEATER

Foster Wheeler oil or gas fired oil heater with a capacity of 10,000 lbs. per hour, with 300° F. temperature increase — Complete with controls — Unit has been used less than 100 hours.

Any reasonable offer will be accepted.

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150 h.p. Murray Water Tube Boiler complete with burner, forced draft fan with motor, and automatic controls. Good condition. Boiler now in service.

NEUHOFF BROS., PACKERS
Dallas, Texas

and William Clements in the Pacific, north coast and mountain regions, headquarters in Los Angeles. These new appointees were formerly members of the field sales staff of the Brown Instruments Division of Minneapolis-Honeywell Regulator Company.

Koven Names Director

Kenneth H. Mac Watt has been appointed director of engineering sales of L. O. Koven & Brother, Inc., Jersey City, N. J., manufacturers of boilers, tanks, special process equipment and weldments. He succeeds W. D. Birch who resigned. Mac Watt received his degree in mechanical engineering from Stevens Institute of Technology. Before joining the company, he was employed by Tidewater Oil Company and Alco Products Division of American Locomotive Company, the latter in an engineering capacity. From 1941 to 1946 he was naval coordinator in charge of contracts with the Navy Department for Gibbs & Cox, Inc.

Mac Watt

Air Reduction Lists Changes

H. R. Salisbury has been appointed president of Air Reduction Sales Company. He has been with the organization over 23 years in various executive capacities. Vice presidents named include H. F. Henriques, general sales; J. J. Lincoln, Jr., railroad sales and sales services; S. B. Stouffer, distribution; N. L. Wisser, field office management. Other officers of the company are: C. G. Andrew, vice president, operating; J. D. Gunther, secretary; W. Winters, treasurer; and J. E. Slater, controller.

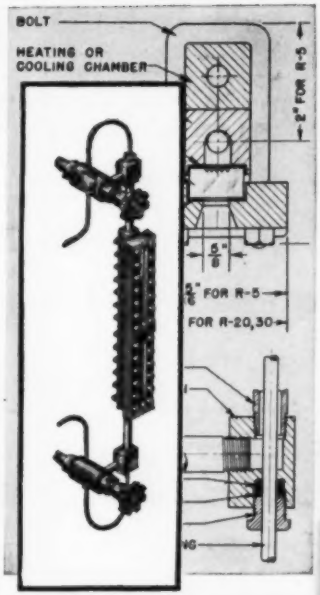
English Firm to Manufacture Hammel-Dahl Control Valves

Hammel-Dahl Company, Providence, R. I., has employed J. Blakeborough & Sons, Ltd., Brighouse, Yorks, Eng., for the manufacture of its automatic control valves. Blakeborough & Sons, Ltd., will operate substantially from its 100 offices in the British Empire outside of Canada, the Scandinavian countries, the Near East, and, broadly speaking, in the Eastern hemisphere, "thus making it possible for Hammel-Dahl Company to provide sales and service practically on a worldwide basis." The European concern has acquired a new plant adjacent to its existing works, which will be staffed with specialists in the design and production of control valves.

Graver Water Conditioning Opens New Branch Offices

Graver Water Conditioning Company, a division of Graver Tank & Manufacturing Company, Inc. has established new sales and field engineering offices at Cleveland, Suite 1101, Hippodrome Building, and at Philadelphia, Suite 1012, Commercial Trust Building. The Cleveland office is in charge of Herman Ross, formerly assistant manager of the Chicago district office, and the Philadelphia office is headed by Robert Schenker, who has recently joined the company.

General offices of the company are at 216 West 14th Street, New York 11, where the administrative, sales, technical and engineering departments are located, together with complete chemical laboratory, pilot plant, warehouse and assembly facilities.



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USE Jerguson Heated Gages for accuracy if you are dealing with high viscosity liquids that flow sluggishly.

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In either case, Jerguson engineers have the answer, with a complete line of gages that give accurate reading of *all* liquids under *all* temperature conditions.

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Illustration shows Internal Tube Model, Reflex Type, with No. 93 Valves. Write for Data Unit No. 17.

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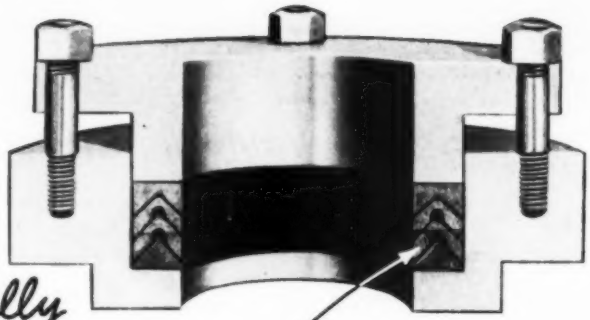

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CHEVRON Packing

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Los Angeles, Calif.

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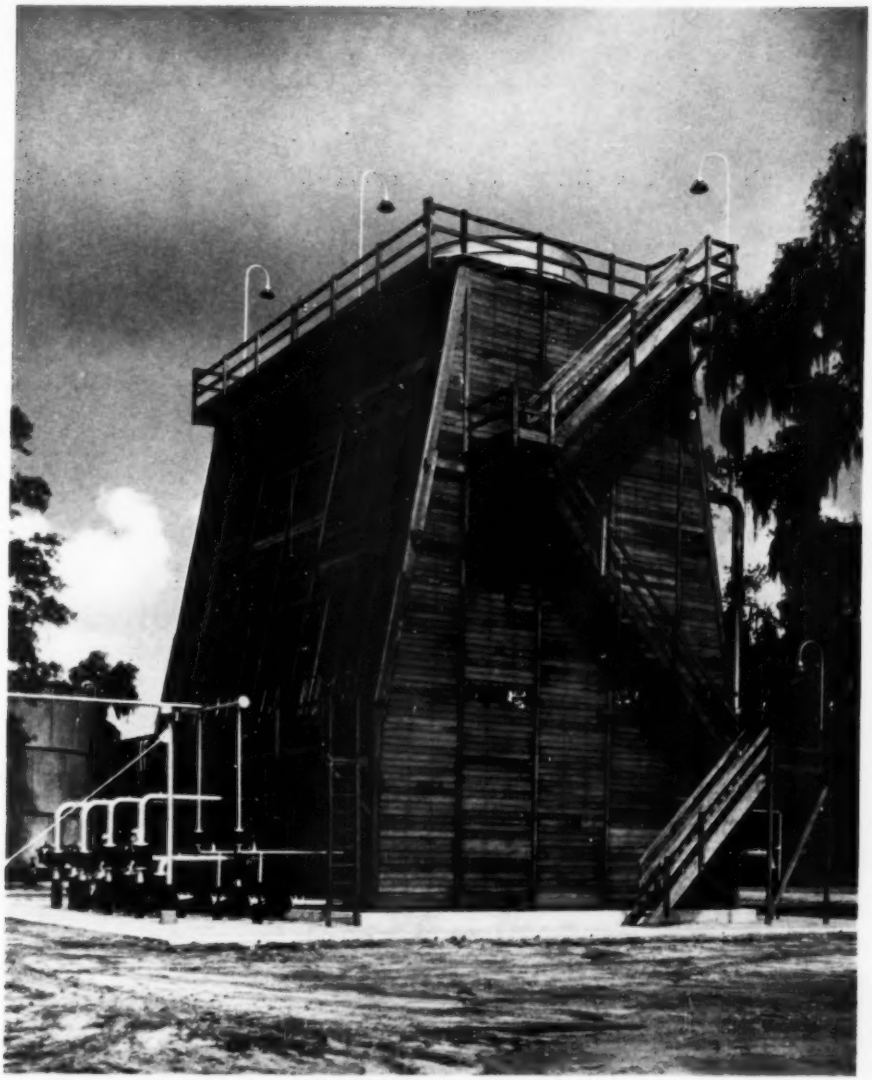

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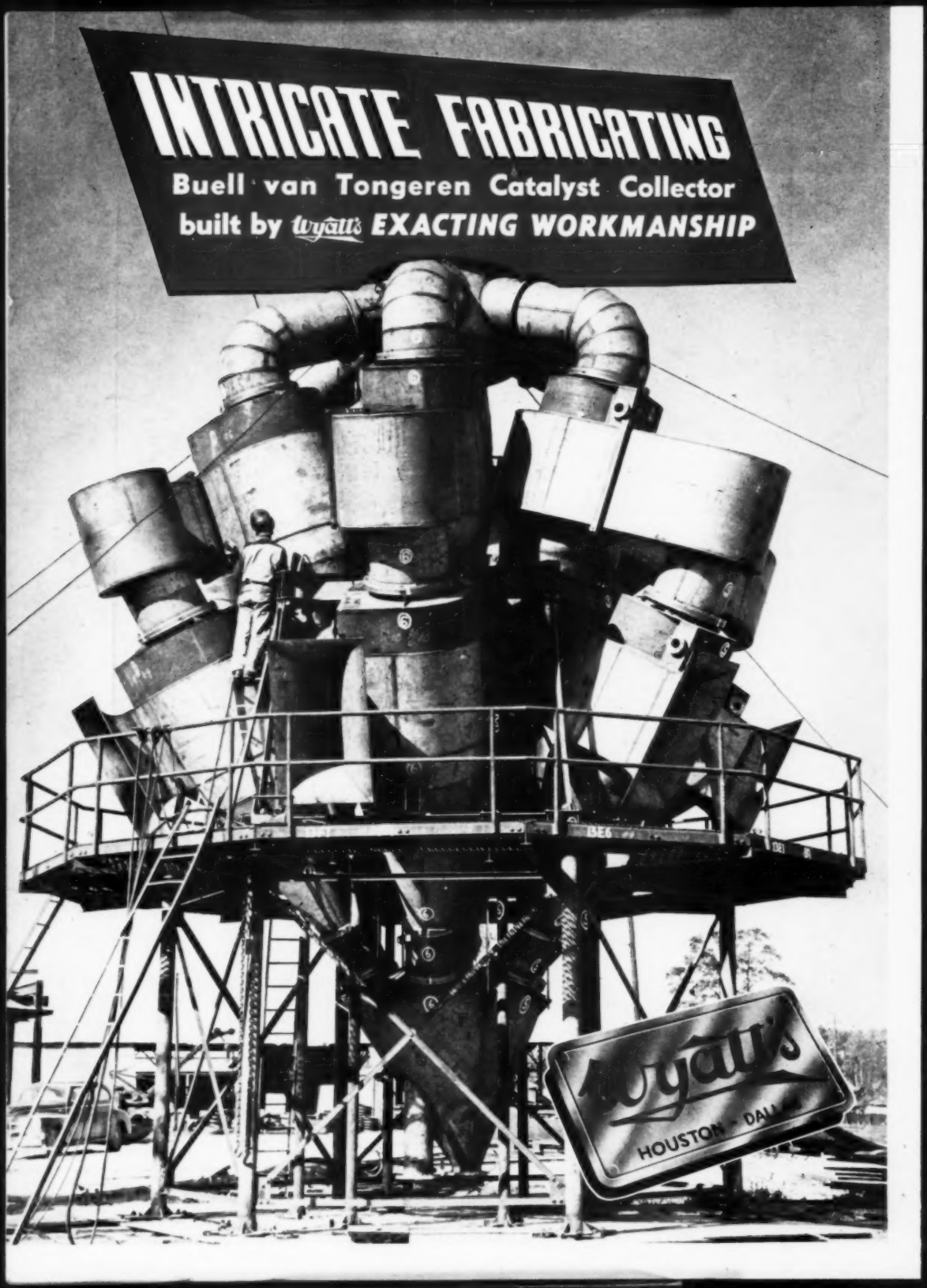
HUDSON ENGINEERING CORPORATION

FAIRVIEW STATION HOUSTON, TEXAS


INTRICATE FABRICATING
Buell van Tongeren Catalyst Collector
built by Wyatt's EXACTING WORKMANSHIP
Wyatt's
HOUSTON - DAL